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<b>(21) International Application Number:</b> PCT/US96/02957 <b>(22) International Filing Date:</b> 1 March 1996 (01.03.96)  <b>(30) Priority Data:</b> 08/397,651      1 March 1995 (01.03.95)      US 08/469,427      6 June 1995 (06.06.95)      US 08/569,063      6 December 1995 (06.12.95)      US  <b>(71) Applicants:</b> LUDWIG INSTITUTE FOR CANCER RE- SEARCH [US/US]; 1345 Avenue of the Americas, New York, NY 10105 (US). HELSINKI UNIVERSITY LI- CENSING LTD., OY [FI/FI]; P.O. Box 26, FIN-00014 Helsinki (FI).  <b>(72) Inventors:</b> ERIKSSON, Ulf; Haegervægen 27, S-746 34 Balsta (SE). OLOFSSON, Birgitta; Kling, Hornsgatan 106, 3 tr, S- 117 26 Stockholm (SE). ALITALO, Kari; Nyyrikintie 4 A, FIN-02100 Espoo (FI). PAJUSOLA, Katri; Kasteholmantie 4 A 8, FIN-00900 Helsinki (FI).  <b>(74) Agent:</b> EVANS, Joseph, D.; Evenson, McKeown, Edwards & Lenahan, Suite 700, 1200 G Street N.W., Washington, DC 20005 (US).		<b>(81) Designated States:</b> AU, CA, CN, FI, JP, NO, NZ, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>With amended claims.</i>
<b>(54) Title:</b> VASCULAR ENDOTHELIAL GROWTH FACTOR-B  <b>(57) Abstract</b>  VEGF-B polypeptides from the PDGF family of growth factors having the property of promoting mitosis and proliferation of vascular endothelial cells, DNA sequences encoding these polypeptides, pharmaceutical compositions containing them and antibodies which react with them. The VEGF-B polypeptides are useful in stimulating angiogenesis as well as in diagnostic applications.		

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## VASCULAR ENDOTHELIAL GROWTH FACTOR-B

### Background of the Invention

Angiogenesis, or the proliferation of new capillaries from pre-existing blood vessels, is a fundamental process necessary for normal growth and development of tissues. It is a prerequisite for the development and differentiation of the vascular tree, as well as for a wide variety of fundamental physiological processes including embryogenesis, somatic growth, tissue and organ repair and regeneration, cyclical growth of the corpus luteum and endometrium, and development and differentiation of the nervous system. In the female reproductive system, angiogenesis occurs in the follicle during its development, in the corpus luteum following ovulation and in the placenta to establish and maintain pregnancy. Angiogenesis additionally occurs as part of the body's repair processes, e.g. in the healing of wounds and fractures. Angiogenesis is also a factor in tumor growth, since a tumor must continuously stimulate growth of new capillary blood vessels in order to grow.

Capillary blood vessels consist of endothelial cells and pericytes. These two cell types carry all of the genetic information to form tubes, branches and entire capillary networks. Specific angiogenic molecules can initiate this process. In view of the physiological importance of angiogenesis, much effort has been devoted to the isolation, characterization and purification of factors that can stimulate angiogenesis. A number of polypeptides which stimulate angiogenesis have been purified and

characterized as to their molecular, biochemical and biological properties. For reviews of such angiogenesis regulators, see Klagsbrun et al., "Regulators of Angiogenesis", *Ann. Rev. Physiol.*, 53:217-39 (1991); and  
5 Folkman et al., "Angiogenesis," *J. Biol. Chem.*, 267:10931-934 (1992). Recent results have implicated several endothelial receptor tyrosine kinases (RTKs) in the establishment and maintenance of the vascular system.

One such growth factor, which is highly specific as a  
10 mitogen for vascular endothelial cells, is termed vascular endothelial growth factor (VEGF). See Ferrara et al., "The Vascular Endothelial Growth Factor Family of Polypeptides," *J. Cellular Biochem.*, 47:211-218 (1991); Connolly, "Vascular Permeability Factor: A Unique Regulator of Blood Vessel  
15 Function," *J. Cellular Biochem.*, 47:219-223 (1991). VEGF is a potent vasoactive protein that has been detected in media conditioned by a number of cell lines including bovine pituitary follicular cells. VEGF is a glycosylated cationic 46-48 kD dimer made up of two 24 kD subunits. It is  
20 inactivated by sulfhydryl reducing agents, resistant to acidic pH and to heating, and binds to immobilized heparin. VEGF is sometimes referred to as vascular permeability factor (VPF) because it increases fluid leakage from blood vessels following intradermal injection. It also has been  
25 called by the name vasculotropin.

Four different molecular species of VEGF have been detected. The 165 amino acid species has a molecular weight of approximately 46 kD and is the predominant molecular form found in normal cells and tissues. A less abundant, shorter  
30 form with a deletion of 44 amino acids between positions 116 and 159 (VEGF<sub>121</sub>), a longer form with an insertion of 24 highly basic residues in position 116 (VEGF<sub>189</sub>), and another longer form with an insertion of 41 amino acids (VEGF<sub>206</sub>), which includes the 24 amino acid insertion found in VEGF<sub>189</sub>,  
35 are also known. VEGF<sub>121</sub> and VEGF<sub>165</sub> are soluble proteins. VEGF<sub>189</sub> and VEGF<sub>206</sub> appear to be mostly cell-associated. All

of the isoforms of VEGF are biologically active. For example, each of the species when applied intradermally is able to induce extravasation of Evans blue.

5 The various species of VEGF are encoded by the same gene and arise from alternative splicing of messenger RNA. This conclusion is supported by Southern blot analysis of human genomic DNA, which shows that the restriction pattern is identical using either a probe for VEGF<sub>165</sub> or one which contains the insertion in VEGF<sub>206</sub>. Analysis of genomic clones  
10 in the area of putative mRNA splicing also shows an intron/exon structure consistent with alternative splicing.

The different isoforms of VEGF have different chemical properties which may regulate cellular release, compartmentalization, bioavailability and possibly also  
15 modulate the signalling properties of the growth factors.

Analysis of the nucleotide sequence of the VEGF gene indicates that VEGF is a member of the platelet-derived growth factor (PDGF) family. VEGF and PlGF are ligands for two endothelial RTKs, flt-1 (VEGF receptor 1, VEGFR1) and  
20 flk-1/KDR (VEGF receptor 2, VEGFR2). The amino acid sequence of VEGF exhibits approximately 20% homology to the sequences of the A and B chains of PDGF, as well as complete conservation of the eight cysteine residues found in both mature PDGF chains. VEGF<sub>165</sub>, VEGF<sub>185</sub> and VEGF<sub>206</sub> also contain  
25 eight additional cysteine residues within the carboxy-terminal region. The amino-terminal sequence of VEGF is preceded by 26 amino acids corresponding to a typical signal sequence. The mature protein is generated directly following signal sequence cleavage without any intervening  
30 prosequence. The existence of a potential glycosylation site at Asn<sup>74</sup> is consistent with other evidence that VEGF is a glycoprotein, but the polypeptide has been reported to exist in both glycosylated and deglycosylated species.

Like other cytokines, VEGF can have diverse effects  
35 that depend on the specific biological context in which it is found. VEGF and its high affinity receptors flt-1 and

KDR/flk-1 are required for the formation and maintenance of the vascular system as well as for both physiological and pathological angiogenesis. VEGF is a potent endothelial cell mitogen and directly contributes to induction of angiogenesis in vivo by promoting endothelial cell growth during normal embryonic development, wound healing, and tissue regeneration and reorganization. VEGF is also involved in pathological processes such as growth and metastasis of solid tumors and ischemia-induced retinal disorders. A most striking property of VEGF is its specificity. It is mitogenic in vitro at 1 ng/ml for capillary and human umbilical vein endothelial cells, but not for adrenal cortex cells, corneal or lens epithelial cells, vascular smooth muscle cells, corneal endothelial cells, granulosa cells, keratinocytes, BHK-21 fibroblasts, 3T3 cells, rat embryo fibroblasts, human placental fibroblasts and human sarcoma cells. The target cell specificity of VEGF is thus restricted to vascular endothelial cells. VEGF can trigger the entire sequence of events leading to angiogenesis and stimulates angiogenesis in vivo in the cornea and in a healing bone graft model. It is able to stimulate the proliferation of endothelial cells isolated from both small and large vessels. Expression of VEGF mRNA is temporally and spatially related to the physiological proliferation of capillary blood vessels in the ovarian corpus luteum or in the developing brain. VEGF expression is triggered by hypoxia so that endothelial cell proliferation and angiogenesis appear to be especially stimulated in ischemic areas. VEGF is also a potent chemoattractant for monocytes. In addition, VEGF induces plasminogen activator and plasminogen activator inhibitor in endothelial cells.

Tumor cells release angiogenic molecules such as VEGF, and monoclonal antibodies to VEGF have been shown to inhibit the growth of certain types of tumor such as rhabdomyosarcoma. See Kim et al., "Inhibition of Vascular

Endothelial Growth Factor-Induced Angiogenesis Suppresses Tumor Growth in vivo," Nature, 362:841-844 (1993). This suggests that blocking VEGF action is of potential therapeutic significance in treating tumors in general, and  
5 highly-vascularized, aggressive tumors in particular.

#### Summary of the Invention

It is an object of the invention to provide a new growth factor having the property of promoting proliferation  
10 of endothelial cells.

Another object of the invention is to provide isolated DNA sequences which encode a new growth factor which promotes proliferation of endothelial cells.

It is also an object of the invention to provide new  
15 products which may be useful in diagnostic and/or therapeutic applications.

These and other objects are achieved in accordance with the present invention by providing an isolated DNA which codes for a protein exhibiting the following characteristic  
20 amino acid sequence (SEQ ID NO:16):

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys  
and having the property of promoting proliferation of endothelial cells or mesodermal cells, the DNA being  
selected from the group consisting of the DNA of Figures 1  
25 and 2 (SEQ ID NO:1), the DNA of Figure 3 (SEQ ID NO:4), the DNA of Figure 5 (SEQ ID NO:6); the DNA of Figure 7 (SEQ ID NO:8), the DNA of Figure 10 (SEQ ID NO:10), the DNA of Figure 12 (SEQ ID NO:12), the DNA of Figure 14 (SEQ ID NO:14), and DNA's which hybridize under stringent conditions  
30 with at least one of the foregoing DNA sequences.

In accordance with further aspects of the invention, the objects are also achieved by providing a protein exhibiting the following characteristic amino acid sequence

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys  
35 (SEQ ID NO:16) and having the property of promoting proliferation of endothelial cells or mesodermal cells,

which protein comprises a sequence of amino acids substantially corresponding to an amino acid sequence selected from the group consisting of the amino acid sequence of Figure 1 (SEQ ID NO:2), the amino acid sequence of Figure 2 (SEQ ID NO:3), the amino acid sequence of Figure 4 (SEQ ID NO:5), the amino acid sequence of Figure 6 (SEQ ID NO:7), the amino acid sequence of Figure 8 (SEQ ID NO:9), the amino acid sequence of Figure 11 (SEQ ID NO:11), the amino acid sequence of Figure 13 (SEQ ID NO:13), and the amino acid sequence of Figure 15 (SEQ ID NO:15).

In further aspects of the invention, the objects are achieved by providing pharmaceutical preparations which comprise such proteins; and by providing antibodies which react with or recognize such proteins.

The novel growth factor of the present invention, referred to hereinafter as vascular endothelial growth factor B or VEGF-B, has close structural similarities to VEGF and to placenta growth factor (PlGF). All of the VEGF-B forms contain the characteristic amino acid sequence

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys (SEQ ID NO:16) (wherein Xaa represents a variable residue), which is an earmark of the PDGF/VEGF family of growth factors. This characteristic amino acid sequence can be found at amino acids 70 to 82 in Figures 4, 6, 8, 11, 13 and 15.

Clinical applications of the invention include diagnostic applications, acceleration of angiogenesis in wound healing, and inhibition of angiogenesis. Quantitation of VEGF-B in cancer biopsy specimens may be useful as an indicator of future metastatic risk. Topical application of VEGF-B preparations to chronic wounds may accelerate angiogenesis and wound healing. VEGF-B may be used in a manner analogous to VEGF.

According to yet further aspects of the invention, the objects are achieved by providing diagnostic/prognostic means typically in the form of test kits. For example, in

one embodiment of the invention there is provided a diagnostic/prognostic test kit comprising antibodies to the new growth factor of the invention and means for detecting, and more preferably evaluating, binding between the antibodies and the new growth factor of the invention. In one preferred embodiment of the diagnostic/prognostic means according to the invention, either the antibody or the new growth factor is labelled, and either the antibody or the growth factor is substrate-bound, such that the growth factor-antibody interaction can be established by determining the amount of label attached to the substrate following binding between the antibody and the growth factor. In a particularly preferred embodiment of the invention, the diagnostic/prognostic means may be provided as a conventional ELISA kit.

In another alternative embodiment, the diagnostic/prognostic means may comprise PCR means for establishing the genomic sequence structure of a VEGF-B gene of a test individual and comparing this sequence structure with that disclosed in this application in order to detect any abnormalities, with a view to establishing whether any aberrations in VEGF-B expression are related to a given disease condition.

A yet further aspect of the invention concerns an antibody which recognizes VEGF-B and which is suitably labelled.

Another aspect of the invention concerns the provision of a pharmaceutical composition comprising either VEGF-B protein or antibodies thereto. Compositions which comprise VEGF-B protein may optionally further comprise either VEGF or heparin or both.

According to an additional aspect of the invention the manufacture of a medicament is provided which comprises VEGF-B protein and heparin for treating conditions characterized by lack of, or reduction in, angiogenesis.

In another aspect, the invention relates to a protein dimer comprising VEGF-B protein, particularly a disulfide-linked dimer. The protein dimers of the invention include both homodimers of VEGF-B protein and heterodimers of VEGF-B and VEGF.

According to a yet further aspect of the invention there is provided a method for facilitating release of VEGF and/or VEGF-B from a cell comprising exposing a cell which expresses either or both of the aforementioned growth factors to heparin.

Another aspect of the invention involves providing a vector comprising an anti-sense nucleotide sequence which is complementary to at least a part of the DNA sequences disclosed herein which encode the new growth factor of the invention which promotes proliferation of endothelial cells. According to a yet further aspect of the invention such a vector comprising an anti-sense sequence may be used to inhibit, or at least mitigate, VEGF-B expression. The use of a vector of this type to inhibit VEGF-B expression is favored in instances where VEGF-B expression is associated with a disease such as in instances where tumors produce VEGF-B in order to provide for angiogenesis. Transformation of such tumor cells with a vector containing an anti-sense nucleotide sequence would suppress or retard angiogenesis and so would inhibit or retard growth of the tumor.

#### Brief Description of the Drawings

Figure 1 shows the nucleotide sequence of the (partial) cDNA clone of VEGF-B (SEQ ID NO:1) and the amino acid sequence of the protein segment (SEQ ID NO:2) coded by the first reading frame of the cDNA;

Figure 2 repeats the nucleotide sequence of the (partial) cDNA clone of VEGF-B (SEQ ID NO:1) and the amino acid sequence of the protein segment (SEQ ID NO:3) coded by the second reading frame of the cDNA;

Figure 3 shows the nucleotide sequence of the coding region of a full length cDNA clone of murine VEGF-B<sub>167</sub> (SEQ ID NO:4);

Figure 4 shows the amino acid sequence of murine VEGF-B<sub>167</sub> (SEQ ID NO:5);

Figure 5 shows the nucleotide sequence of the coding region of a cDNA clone of VEGF-B<sub>174</sub> (SEQ ID NO:6);

Figure 6 shows the amino acid sequence of VEGF-B<sub>174</sub> (SEQ ID NO:7);

Figure 7 shows the nucleotide sequence of a cDNA clone of VEGF-B<sub>112</sub> (SEQ ID NO:8);

Figure 8 shows the amino acid sequence of VEGF-B<sub>112</sub> (SEQ ID NO:9);

Figure 9 shows a comparison of the amino acid sequences of mVEGF-B<sub>167</sub>, mVEGF<sub>164</sub>, hPlGF, mPDGF A, and mPDGF B;

Figure 10 shows the nucleotide sequence of a clone of human VEGF-B<sub>167</sub> (SEQ ID NO:10);

Figure 11 shows the amino acid sequence of human VEGF-B<sub>167</sub> (SEQ ID NO:11); and

Figure 12 shows the nucleotide sequence of murine VEGF-B<sub>186</sub> (SEQ ID NO:12);

Figure 13 shows the amino acid sequence of murine VEGF-B<sub>186</sub> (SEQ ID NO:13);

Figure 14 shows the nucleotide sequence of human VEGF-B<sub>186</sub> (SEQ ID NO:14);

Figure 15 shows the amino acid sequence of human VEGF-B<sub>186</sub> (SEQ ID NO:15);

Figure 16 shows an amino acid sequence comparison of murine and human VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> isoforms (SEQ ID NOS: 5, 11, 13 & 15).

Figure 17 shows the schematic structure of mouse and human genes for VEGF-B;

Figure 18 shows a hydrophilicity analysis of murine VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> isoforms;

Figure 19 shows a phylogenetic analysis of the VEGF/PDGF family of growth factors;

Figure 20 is a graph showing the induction of [<sup>3</sup>H]thymidine incorporation by VEGF-B, VEGF and bFGF for human umbilical vein endothelial cells (HUVEC) and bovine capillary endothelial (BCE) cells;

5        Figure 21 is a Northern blot analysis of the expression of VEGF-B<sub>186</sub> transcripts in several mouse and human tissues;

Figure 22 shows the results of immunoprecipitation and SDS-PAGE analysis of cell culture media and detergent solubilized cell lysates from Cos-1 cells transiently  
10       transfected with a murine VEGF-B cDNA;

Figure 23A shows the results of immunoprecipitation and SDS-PAGE analysis of cell culture media from transfected Cos-1 cells separately expressing murine VEGF-B<sub>186</sub> and human VEGF<sub>165</sub>;

15       Figure 23B shows the results of immunoprecipitation and SDS-PAGE analysis of cell culture media (M) and detergent solubilized cell lysates (L) of Cos-1 cells which coexpress murine VEGF-B<sub>186</sub> and human VEGF<sub>165</sub>;

Figure 23C shows the results of immunoprecipitation and  
20       SDS-PAGE analysis of cell culture media from Cos-1 cells expressing murine VEGF-B<sub>186</sub> and human VEGF, either separately or in combination, and from mock transfected control cells;

Figure 24 is a schematic illustration of the derivation of VEGF-B promoter-reporter clones; and

25       Figure 25 shows the nucleotide sequence of a 1.55 kb human VEGF-B promoter fragment (SEQ ID NO:17).

#### Detailed Description of Preferred Embodiments

The present invention thus is directed to new vascular  
30       endothelial growth factors, hereinafter referred to as VEGF-B growth factors, which share the angiogenic and other properties of VEGF, but which are distributed and expressed in tissues differently from VEGF.

VEGF-B growth factors are members of the family of  
35       platelet derived growth factors and are a growth factors which promote mitosis and proliferation of vascular

endothelial cells and/or mesodermal cells. They are produced by expression of DNA sequences which correspond to, or which are hybridizable under stringent conditions with, any one of the DNA sequences depicted in Figures 1 and 2 (SEQ ID NO:1), Figure 3 (SEQ ID NO:4), Figure 5 (SEQ ID NO:6), Figure 7 (SEQ ID NO:8), Figure 10 (SEQ ID NO:10), Figure 12 (SEQ ID NO:12) or Figure 14 (SEQ ID NO:14). It is intended to include within the scope of the invention all angiogenic proteins encoded by DNA sequences which hybridize under stringent conditions to any one of the foregoing DNA sequences. Suitable hybridization conditions include, for example, 50% formamide, 5 x SSPE buffer, 5 x Denhardt's solution, 0.5% SDS and 100 µg/ml of salmon sperm DNA at 42°C overnight, followed by washing 2 x 30 minutes in 2 x SSC at 55°C.

The invention is also directed to an isolated and/or purified DNA which corresponds to, or which hybridizes under stringent conditions with, any one of the foregoing DNA sequences.

In a further aspect, the invention is directed to antibodies of VEGF-B growth factors, and particularly to monoclonal antibodies.

VEGF-B proteins are believed to interact with protein tyrosine kinase growth factor receptors. Details of such receptors are known in the art [See e.g. Wilks, A.F., "Protein Tyrosine Kinase Growth Factor Receptors and Their Ligands in Development, Differentiation, and Cancer," *Adv. Cancer Res.*, 60:43-73 (1993)].

Various adult mouse tissues were tested for expression of transcripts corresponding to VEGF-B by Northern blotting. The size of the mRNA was 1.3-1.4 kb. A mouse multiple tissue Northern blot (MTN, Clontech) was probed with the ~0.9 kb SalI/NotI fragment derived from the pPC67 yeast expression vectors described above. The probe was labelled with <sup>32</sup>P-dCTP using random priming (specific activity 10<sup>8</sup>-10<sup>9</sup> cpm/µg of DNA). The blot was hybridized overnight at 42°C

using 50% formamide, 5 x SSPE buffer, 2% SDS, 10 x Denhardt's solution, 100 µg/ml salmon sperm DNA and 1x10<sup>6</sup> cpm of the labelled probe/ml. The blot was washed at room temperature for 2 x 30 min in 2 x SSC containing 0.05% SDS and then for 2 x 20 min at 52°C in 0.1 x SSC containing 0.1% SDS. The blot was then exposed at -70°C for three days using intensifying screens. Kodak XAR film was used. The relative expression levels as determined by visual examinations of the film are listed in the following table:

10

Table 1

Distribution of VEGF-B Transcripts in the Adult Mouse

15

20

Tissue	Relative Expression Level
Heart	+++++
Brain	+++
Spleen	(+)
Lung	++
Liver	+
Skeletal Muscle	++++
Kidney	+++
Testis	(+)

+++++ = very strong expression; ++ = rather weak expression;  
 +++ = strong expression; + = weak expression;  
 ++ = moderate expression; (+) = very weak expression.

25

A human multiple tissue Northern blot (MNT) from Clontech was probed using the murine partial cDNA to determine relative VEGF-B expression levels in various human tissues. The size of the transcript was 1.3-1.4 kb. The conditions were identical to those used for the mouse Northern blot described above. The relative VEGF-B transcript levels for the human Northern blot are listed in the following Table 2. For comparison purposes, Table 2

30

also lists relative expression level data from the literature for VEGF in various mammalian systems.

Table 2

5 Tissues	Relative Expression Levels			
	VEGF-B (Northern blot)	VEGF (from literature)		
	human	human	murine	guinea pig
heart	+++++	++	+++	+++
brain	+		+	+
placenta	+			
10 lung	+	++++		++
liver	(+)	++	(+)	+
skeletal muscle	++++		+++	+
kidney	+	++	+	++
15 pancreas	+++			
spleen	++		-	+
thymus	+		-	
prostate	+++			
testis	++			(+)
20 ovary	+++			-
small intestine	++			
colon	+++			
25 peripheral blood leucocytes	+			

From a comparison of Table 1 and Table 2 it can be seen that mouse and human tissue expression levels of VEGF-B transcripts are relatively similar with the highest expression levels being found in heart and skeletal muscle. Significant differences may be seen in brain and kidney tissue. It should also be noted that tissues containing a

large proportion of both muscular and epithelial cells, such as prostate, pancreas and colon from which some of the most common human tumors originate, express relatively high levels of VEGF-B.

5       A comparison of the relative expression levels of VEGF and VEGF-B in human tissues shows some striking differences. VEGF is expressed rather weakly by human heart tissue, but VEGF-B is very strongly expressed by the same tissue. On the other hand, VEGF is strongly expressed by human lung  
10   tissue, but VEGF-B is only weakly expressed by human lung tissue. In a similar vein, human liver tissue expresses VEGF at a moderate level, but VEGF-B is expressed only very weakly. These data evidence that despite their general similarities, the actions of VEGF and VEGF-B are not  
15   completely identical.

      The expression of VEGF-B transcripts was further analyzed in mouse and human tissues by Northern blotting and compared with the expression of VEGF transcripts. Mouse and human multiple tissue Northern (MTN) blots (Clontech) were  
20   hybridized with a <sup>32</sup>P-labelled mouse VEGF-B probe (=0.9 kb SalI/NotI insert of the clone pcif 2). VEGF expression was analyzed with <sup>32</sup>P-labelled VEGF<sub>165</sub> cDNA as the probe. The hybridizations were carried out at 42°C in 50% deionized formamide, 5 x SSC pH 7.0, 1% SDS, 5 x Denhardt's solution  
25   and 100 µg/ml of denatured salmon sperm DNA. The filters were washed 2 x 30 min at 52°C in 2 x SSC containing 0.5% SDS and exposed to Kodak XAR film for 2-5 days at -70°C using intensifying screens. In situ hybridization analysis  
30   of adult mouse tissues from CBA mice and of embryos derived from matings of CBA and NMRI mice were carried out essentially as previously described by Korhonen et al., *Blood*, 80, 2548-55 (1992). The RNA probes (a 383 bp antisense probe and a 169 bp sense probe) were generated from a linearized plasmid containing a 440 bp Sal I/Sac I  
35   fragment derived from the pcif 2 cDNA clone. Radiolabelled RNA was synthesized using T7 and SP6 RNA polymerases and

[<sup>35</sup>S]UTP (Amersham Inc.). Alkaline hydrolysis of the probes was omitted. Hematoxylin was used for counterstaining. Control hybridizations with sense strand and RNase A-treated sections did not give signals above background.

5        In mouse tissues the most abundant expression of the 1.4 kb VEGF-B transcript was detected in heart, brain, skeletal muscle, and kidney. The major 3.7 kb VEGF transcript was is expressed in heart, brain, lung, skeletal muscle and kidney. In human tissues, the most abundant  
10       expression of the 1.4 kb VEGF-B transcript and the major 3.7 and 4.5 kb VEGF transcripts were detected in heart, skeletal muscle, pancreas and prostate. Thus, although clear quantitative differences exist, it appears that VEGF-B and VEGF are coexpressed in many human and mouse tissues.

15       The expression of VEGF-B transcripts was further examined by in situ hybridization in sections from adult mouse heart and skeletal muscle and from the early (E 10) mouse embryo. In the adult heart, VEGF-B transcripts are prominently expressed in the myocardium, while no specific  
20       signal is detected in arterial smooth muscle. In adult striated muscle, VEGF-B transcripts are expressed by some of the myofibers whereas others seem to lack the transcript. In the E 10 mouse embryo, VEGF-B transcripts are detected  
25       mainly in the developing heart. The myocardium of the adult mouse heart has a prominent signal. In striated muscle, VEGF-B expression is seen in subpopulations of myofibers. Strong signals were also obtained in the developing heart of the E10 mouse embryo. Other embryonic structures expressed lower or undetectable levels of transcripts for VEGF-B.  
30       Taken together, these tests indicate that VEGF-B transcripts are expressed primarily in muscular tissues. VEGF-B is particularly abundant in heart and skeletal muscle and is co-expressed with VEGF in these and other tissues. In transfected cells, VEGF-B forms cell surface associated,  
35       disulfide-linked homodimers and heterodimers with VEGF when coexpressed. A Northern blot analysis of the expression of

VEGF-B<sub>186</sub> transcripts in several mouse and human tissues using a VEGF-B<sub>186</sub> isoform specific probe is shown in Figure 21.

The chromosomal location of the VEGF-B gene was assessed by Southern blotting and polymerase chain reaction analysis of somatic cell hybrids and fluorescence in situ hybridization (FISH) of metaphase chromosomes. The VEGF-B gene was found on chromosome 11q13, proximal of the cyclin D1 gene. It is interesting that although the cyclin D1 gene is amplified in a number of human carcinomas, the VEGF-B gene was not amplified in several mammary carcinoma cell lines which contained amplified cyclin D1. Nevertheless, mutations in the VEGF-B gene may be related to vascular malformations and/or cardiovascular diseases.

Unless otherwise indicated, the following Examples used standard molecular biology techniques and procedures as disclosed in Ausubel et al. (eds.), *Current Protocols in Molecular Biology*, John Wiley & Sons, New York (1992).

Example 1: Partial cDNA clone with two reading frames.

A partial cDNA clone encoding murine VEGF-B was identified as follows. A cDNA library (E 14.5) derived from poly A<sup>+</sup> mRNA isolated from 14.5 day old mouse embryos [Chevray P. and Nathans D., "Protein interaction cloning in yeast: Identification of mammalian proteins that react with the leucine zipper of Jun," *Proc. Natl. Acad. Sci. USA*, 89:5789-93 (1992)] was screened for cellular proteins which potentially might interact with cellular retinoic acid-binding protein type 1 (CRABP-I) using a yeast two-hybrid interaction trap screening technique as described by Gyuris J., Golemis E., Chertkov H. and Brent R., "Cdk1, a Human G1 and S Phase Protein Phosphatase That Associates with Cdk2," *Cell*, 75:791-803 (1993). This screening technique involves a fusion protein that contains a binding domain and that is known to be transcriptionally inert (the "bait"); reporter genes that have no basal transcription and that are bound by the bait; and an expression library which encodes proteins

expressed as chimeras and whose amino termini contain an activation domain and other useful moieties (the "prey"). The screened library was a 14.5 day mouse embryo plasmid library in the yeast expression vector pPC67 obtained from Dr. Pierre Chevray of the Johns Hopkins University, School of Medicine, 725 North Wolfe St., Baltimore, MD 21205. A positive cDNA clone (pcif-2) was recovered from the screening. The positive clone was sequenced using well known, conventional techniques and found to encode a protein highly homologous to VEGF and the other members of the PDGF family of growth factors. The  $\approx 0.9$  kb SalI/NotI insert in the plasmid pPC67 was cloned into pBluescript and fully sequenced using T7 and T3 vector primers together with internal primers. The plasmid pBluescript is commercially available from Stratagene Inc., LaJolla, California. The cDNA insert was found to be 886 base pairs long and to encode two polypeptides in different reading frames which were homologous to the N-terminal end and the C-terminal end, respectively, of VEGF. This novel growth factor is referred to hereinafter as VEGF-B. The clone is partial and lacks several amino acids in the amino terminal region and the entire signal sequence.

Figure 1 shows the nucleotide sequence (SEQ ID NO:1) of this partial cDNA clone of VEGF-B and the amino acid sequence (SEQ ID NO:2) encoded in the first reading frame thereof. The DNA sequence of Figure 1 was obtained by conventional sequencing of a clone (pcif-2) in the yeast expression vector pPC67. The clone comprised 886 base pairs and encoded a part of murine VEGF-B.

The isolated cDNA sequence will hybridize with the mammalian genomic DNA, e.g. either murine or human, which contains the VEGF-B gene. In addition to the coding sequence, the genomic DNA will contain one or more promoter sequence(s) which give and direct expression of VEGF-B in one or more specific tissues. Thus the coding sequence of VEGF-B may be linked to muscle-specific promoter elements

which in turn are specific to certain types of muscle fibers.

The nucleotide sequence is translated in two different reading frames into two different amino acid sequences. There is a stop codon (TGA) within the coding sequence at base pairs 309-311. Thus, VEGF-B comes in several splicing variants. The 5' end of the cloned cDNA sequence encodes an 102 amino acid long protein with significant homology to the N-terminal domains of VEGF, PlGF and PDGF A and B. In particular, a number of cysteine residues are perfectly conserved within this group of proteins. In addition to the nucleotide sequence (SEQ ID NO:1), Figure 1 further depicts the deduced amino acid sequence (SEQ ID NO:2) of this first protein.

Translation of the C-terminal end of the cDNA (base pairs 308-475) in a different reading frame results in a protein which is highly homologous to the C-terminal part of VEGF<sub>165</sub>, VEGF<sub>189</sub>, and VEGF<sub>206</sub>. Figure 2 again shows the nucleotide sequence (SEQ ID NO:1) of Figure 1, but this time includes the deduced amino acid sequence (SEQ ID NO:3) of the second protein, which is encoded in the second reading frame and is 54 amino acids long. It thus appears that the VEGF-B gene encodes different proteins using alternative splicing of the primary transcript. The last part of the clone, encoding the second peptide might be expressed as a functional protein in other spliced variants of VEGF-B.

The aforescribed proteins may exist in combined association with an additional N-terminal sequence of approximately five (5) to ten (10) amino acids, as well as a further leader sequence of approximately twenty-one (21) to twenty-eight (28) amino acids. Inasmuch such combined amino acid sequences exhibit the property of promoting the proliferation of endothelial cells and the DNA sequences which code for such combined peptide sequences will hybridize under stringent conditions with the DNA sequence of Figures 1 and 2, such amino acid sequences and the DNA

which codes for them are expressly contemplated to be within the scope of the present invention.

Example 2: Cloning of full length cDNA's for mouse VEGF-B.

5        Using the approximately 0.9 kb SalI/NotI cDNA insert of the previously identified cDNA clone of Example 1 as a probe, an adult mouse heart lambda ZAP-II cDNA library obtained from Stratagene Inc., of La Jolla, California was screened using standard techniques. The library was  
10        titrated and plated as recommended and filters were prepared. Following prehybridization at 42 °C in 50 % formamide, 5 x SSPE, 5 x Denharts solution, 1 % SDS and 100 ug of salmon sperm DNA/ml, the filters were hybridized at the same temperature and in the same solution containing the  
15        denatured radiolabelled probe using 10<sup>6</sup> cpm/ml of hybridization solution. The probe was labelled using a random priming kit (Amersham). After 16 hours the filters were washed in 2 x SSC containing 0.5 % SDS for 2 x 30 mins at 52 °C. The filters were exposed overnight using  
20        intensifying screens at -70 °C. Positive clones were rescreened two times until all plaques on a plate were positive. The inserts from several positive clones were subcloned into the plasmid pBluescript SK+ by in vivo excision as recommended by the supplier.

25        Several clones were mapped by restriction enzyme analysis and were found to fall into two distinct groups characterized by the length of a SpeI/BamHI restriction fragment. The first of these groups comprised three of the restriction mapped clones which each had a 240 bp SpeI/BamHI  
30        restriction fragment. The other group comprised a clone which had a 340 bp SpeI/BamHI fragment. Analysis of this fragment is described in Example 5.

      The three clones which exhibited the 240 bp SpeI/BamHI restriction fragment were fully or partially sequenced  
35        (Sequenase 2.0, U.S. Biochemicals), and the characteristics of the clones are summarized as follows:

Nucleotide sequence analyses revealed that two of the cDNA clones were substantially identical, although they differed in length, and one had a mutation. One of the clones was full length and contained an open reading frame  
5 encoding 188 amino acid residues in which the first 21 amino acids are a cleavable signal sequence. The other of the two substantially identical clones terminated at the G of the start initiation codon. It could be inferred by sequence analysis of additional clones that the sequence preceeding  
10 the G reads ACCAT. Both of the clones were found to have the same coding region nucleotide sequence, which is depicted in Figure 3 (SEQ ID NO:4). The figure omits the initial thymine and adenine of the start codon (TAG) which were not present in the isolated clones. The deduced amino  
15 acid sequence of the open reading frame of the coding region of both of these two cDNA clones is shown in Figure 4 (SEQ ID NO:5). The resulting protein encoded by this sequence is referred to hereinafter as VEGF-B<sub>167</sub>. In each of the protein names used herein, the subscript number refers to the number  
20 of amino acids in the mature protein without the signal sequence.

As would be expected, a comparison of the amino acid sequence encoded by these two clones with the partial amino acid sequence deduced from cDNA clone of Example 1 showed a  
25 striking similarity. However, the two open reading frames in the clone of Example 1, each of which encoded an amino acid sequence homologous to a different portion of VEGF, are both present in the same reading frame in each of these two clones according to Example 2. The frame shift in the clone  
30 of Example 1 is caused by an insertion of two extra adenine units which displace the C-terminal part of the clone of Example 1 out of frame.. The reason for this is not presently understood, but may be due to a cloning artifact.

The coding part of the third clone had a nucleotide  
35 sequence identical to those of the preceding two clones except for a 21 bp insertion. Figure 5 shows the nucleotide

sequence of this third clone (SEQ ID NO:6). To facilitate identification, the 21 extra bases are underlined in the Figure. This insertion gives rise to 7 additional amino acid residues in the mature protein. Thus the resulting protein encoded by this longer cDNA is termed VEGF-B<sub>174</sub>. The amino acid sequence of the protein encoded by the cDNA of Figure 5 is depicted in Figure 6 (SEQ ID NO:7). The seven additional amino acids also are underlined in the figure for ease of identification. The additional amino acids are inserted into the sequence in a splice site, and sequencing of mouse genomic DNA clones indicates that these additional amino acids are the result of true alternative splicing. Furthermore, based on what is known about the receptor binding site locations of PDGF, the insertion occurs in a position in the protein which is probably part of a receptor binding site. The insertion is thus likely to affect receptor binding and could be of functional importance in influencing antagonist and/or different receptor specificity.

20

Example 3: Hybrid cDNA clone.

As previously pointed out this original cDNA clone of Example 1 was not full length and may contain an artifact. However, if the extreme 5' nucleotide sequence of the clones which encode VEGF-B<sub>167</sub> and/or VEGF-B<sub>174</sub> is added, the open reading frame encodes a protein of 133 amino acids, yielding a mature protein which is 112 amino acids long and hence is named VEGF-B<sub>112</sub>. The hybrid cDNA sequence encoding VEGF-B<sub>112</sub> (SEQ ID NO:8) is shown in Figure 7, and the amino acid sequence of the corresponding protein (SEQ ID NO:9) is illustrated in Figure 8.

Figure 9 shows a multiple amino acid sequence alignment for comparison purposes of the 167 amino acid variant of mouse Vascular Endothelial Growth Factor B (mVEGF-B<sub>167</sub>), mouse Vascular Endothelial Growth Factor (mVEGF<sub>164</sub>), human Placenta Growth Factor (hPlGF), mouse Platelet Derived Growth Factor

35

A. (mPDGF A), and mouse Platelet Derived Growth Factor B (mPDGF B). Amino acid residues identical to mouse VEGF-B<sub>167</sub> are boxed. The homologous relationship of the sequences is apparent, and the figure clearly demonstrates the conserved structure of the growth factors belonging to the PDGF/VEGF family of growth factors, and that VEGF-B is a structural homolog of the other growth factors of this group. Pairwise comparisons of the amino acid sequences show that mouse VEGF-B is approximately 43% identical to mouse VEGF<sub>164</sub>, approximately 30% identical to human PlGF, and approximately 20% identical to mouse PDGF A and B. The conserved cysteine residues are particularly noteworthy. It can be seen that the first eight cysteine residues in the N-terminal domains (i.e. the PDGF-like domains) of the five growth factors are shared by all members of this family, and it is thus evident that the eight cysteine residues, which are involved in intramolecular and intermolecular disulfide bonding, are invariant among these growth factors. Furthermore, the C-terminal domains of mouse VEGF-B<sub>167</sub> and VEGF<sub>164</sub> also display a significant similarity with eight additional conserved cysteine residues and several stretches of basic amino acids.

Example 4: Cloning of human VEGF-B cDNA.

10<sup>6</sup> λ-clones of human fibrosarcoma cDNA library HT1080 in λgt11 (Clontech) were screened with the ~0.9 kb insert of the mouse VEGF-B clone pcif 2 according to standard procedures. Among several positive clones, one, termed H.1 was analyzed more carefully and its nucleotide sequence was determined. The nucleotide sequence indicated that a 207 amino acid isoform of human VEGF-B was encoded. Analysis of this isoform is described subsequently in Example 6. Based on the H.1 sequence two oligonucleotides were designed that would amplify the whole coding region of putative human cDNA corresponding to mouse VEGF-B<sub>167</sub> isoform:

5'-CACCATGAGCCCTCTGCTCC-3' (forward) (SEQ ID NO:18)

5'-GCCATGTGTCACCTTCGCAG-3' (reverse) (SEQ ID NO:19)

These oligonucleotides were used to amplify by polymerase chain reaction (PCR) the whole coding region of human VEGF-B from oligo-dT primed human erythroleukemia cell (HEL) RNA. The amplified product was cloned into the pCR II-vector of TA cloning kit (Invitrogen) and sequenced using standard techniques. The nucleotide sequence of the human VEGF-B cDNA clone is shown in Fig. 10 (SEQ ID NO:10), and the deduced amino acid sequence of human VEGF-B<sub>167</sub> is shown in Fig. 11 (SEQ ID NO:11).

The full length mouse cDNA clone of Example 2 and the full length human cDNA clone of Example 4 each encode a polypeptide of 188 amino acids containing an N-terminal hydrophobic putative signal sequence. In analogy with VEGF, the signal peptidase cleavage site is believed to be located between Ala 21 and Pro 22. The putative cleavage site of the signal peptidase is indicated in Figure 16 by an arrow. Accordingly, the processed VEGF-B polypeptides of these two clones each contain 167 amino acids.

#### Example 5:

The clone which exhibited the 340 bp SpeI/BamHI fragment isolated in Example 2 was analyzed, and the major portion was found to be identical to the first two clones of Example 2 which exhibited the 240 bp SpeI/BamHI fragment. The difference is due to the presence of an insertion in the C-terminal part of the sequence.

This 340 bp SpeI/BamHI DNA fragment encodes a further isoform of mouse VEGF-B containing 207 amino acids. The coding portion of the DNA encoding this protein (SEQ ID NO:12) is illustrated in Figure 12, and the translated amino acid sequence (SEQ ID NO:13) is illustrated in Figure 13. After cleavage of the 21 amino acid leader sequence, the mature protein contains 186 amino acids and is referred to as mVEGF-B<sub>186</sub>. This isoform is clearly a result of

alternative DNA splicing as described below with reference to Figure 17.

Example 6:

5       The H.1 clone isolated as described in Example 4 was found to encode a 207 amino acid isoform of human VEGF-B. The coding portion of the DNA (SEQ ID NO:14) encoding this protein is illustrated in Figure 14 and the translated amino acid sequence (SEQ ID NO:15) is illustrated in Figure 15.  
10       Again, this isoform, which is designated hVEGF-B<sub>186</sub>, appears to be a product of alternative splicing.

      Both the mVEGF-B<sub>186</sub> of Example 5 and the hVEGF-B<sub>186</sub> of Example 6 include a 101 base pair insertion between nucleotides 414 and 415 of the coding sequence of VEGF-B<sub>167</sub>.  
15       Following the insertion, the nucleotide sequences of these cDNA clones were identical to the corresponding VEGF-B<sub>167</sub> sequences. The position of the 101 base pair insertion corresponds to the exon 5-exon 6 junction in VEGF. The insertion results in a frameshift which causes the C-  
20       terminal domains of the two VEGF-B isoforms to be entirely different.

      The divergence of the C-terminal amino acid sequences starting at amino acid 116 in SEQ ID NOS 11 and 15, which correspond to the two principal VEGF-B isoforms, VEGF-B<sub>167</sub>, and  
25       VEGF-B<sub>186</sub>, is reflected by the different biochemical characteristics of the two isoforms. The C-terminal domain of VEGF-B<sub>167</sub> is strongly basic (net charge +13) and binds heparin. The C-terminal domain of VEGF-B<sub>186</sub> is weakly basic (net charge +5) and has a long stretch of hydrophobic amino  
30       acid residues in its C-terminus. The hydrophobic tail in VEGF-B<sub>186</sub> is unlikely to behave as a transmembrane domain since this variant of VEGF-B is secreted from cells. Therefore, despite an identical N-terminal domain, these two principal isoforms of VEGF-B have very different biochemical  
35       properties. The absence of the highly basic heparin-binding domain from VEGF-B<sub>186</sub> allows the protein to be freely secreted

from cells. However, the secretion of VEGF-B<sub>186</sub> is remarkably slow; in a pulse chase experiment using transfected cells, VEGF-B<sub>186</sub> homodimers were not found in the medium before 1 hour. In contrast, VEGF homodimers and VEGF-B<sub>186</sub>·VEGF dimers  
5 appear in the medium within 30 minutes.

Figure 16 shows the aligned amino acid sequences of mouse and human VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> (SEQ ID NOS:5, 11, 13 & 15) in one-letter code. Identical residues are enclosed in boxes, while amino acid residues which differ between  
10 mouse and human VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> isoforms are outside the boxes. Mouse and human VEGF-B display approximately 88 % amino acid sequence identity and are highly basic, especially in their C-terminal regions. The C-terminal domains of murine and human VEGF-B<sub>186</sub> are approximately 85%  
15 identical at the amino acid level. The C-terminal domains of murine and human VEGF-B<sub>167</sub> are approximately 84% identical at the amino acid level. Both polypeptides lack the consensus sequence for N-linked glycosylation (N-X-T/S). The arrow indicates the putative cleavage site for the  
20 signal peptidase between Ala<sup>21</sup> and Pro<sup>22</sup>. Excluding the signal sequences, the mouse and human VEGF-B<sub>167</sub> amino acid sequences are highly homologous with only 20 replacements out the the 167 residues. The replacements are clustered in  
25 the N-terminus, in two regions around amino acids 60 and 145. All cysteine residues in both VEGF-B<sub>167</sub> proteins are invariant, but the eight cysteine residues in the C-terminal end of VEGF-B<sub>167</sub> are not conserved in the VEGF-B<sub>186</sub> isoforms. It is notable that the mouse and human sequences in the  
30 region between residues 66 and 129 are identical apart from one evolutionarily conserved replacement (Q105R). This is of importance since the receptor binding domains are found within this portion of the protein (compared to PDGF structure). From this it can be concluded that it is likely that mouse and human VEGF-B will exhibit cross-reactive  
35 binding on the receptor level and thus display identical or similar biological activities.

Example 7: Exon-intron structures of mouse and human VEGF-B genes.

The structure of the human VEGF-B gene was determined by restriction mapping and nucleotide sequence analysis of  
5 cloned PCR fragments obtained from PCR reactions employing human genomic DNA as the template, except in the case of the first exon and intron, which were identified from a genomic  $\lambda$ -clone. The structure of the mouse gene was determined by  
10 restriction mapping and nucleotide sequence analysis of cloned PCR fragments amplified using different combinations of primers. As a template in these PCR amplifications an isolated genomic  $\lambda$  clone containing the entire mouse VEGF-B gene was used.

Procedure.

15 Several  $\lambda$  clones for the mouse VEGF-B gene were isolated from a 129/Sw  $\lambda$ FIX genomic library as recommended by the supplier (Stratagene, Inc.). The  $\sim 0.9$  kb Sali/NotI insert of the pcif2 cDNA for VEGF-B (SEQ ID NO:1) was used as the probe.  $\lambda$  DNA from several positive clones were  
20 isolated from plate lysates. One of the positive  $\lambda$ -clones (clone 10) was subcloned as BamHI fragments into pBluescript SK (Stratagene Inc.). Isolated DNA from this same clone was also used as the template in PCR reactions (100 ng of  $\lambda$  DNA/reaction) and the coding parts of the mouse VEGF-B gene  
25 were amplified using different combinations of primers. The nucleotide sequences of these primers were derived from the cDNA clones encoding murine VEGF-B<sub>167</sub> and murine VEGF-B<sub>186</sub>. Taq DNA polymerase (2.5 U/reaction) was used. The generated PCR fragments were directly cloned into the TA-cloning  
30 vector pPCR II (Invitrogen Inc.). The exon-intron structure of the mouse VEGF-B gene was established by nucleotide sequence analysis of the subcloned Bam HI genomic fragments and of the cloned PCR products.

A human genomic  $\lambda$ -clone was isolated by screening 1 x  
35 10<sup>6</sup> clones of a human genomic library in EMBL-3 SP6/T7 (Clontech) using high stringency conditions with a 90 bp

PCR-fragment spanning 5' sequences of human VEGF-B cDNA as the probe. The washing conditions were: one wash at 1 x SSC at room temperature for 30 minutes and two washes at 1 x SSC at 65°C for 30 minutes. Primers for the PCR were:

- 5           5'-CACCATGAGCCCTCTGCTCC-3' (forward) (SEQ ID NO:18) and  
          5'-GGGCATCAGGCTGGGAGACAG-3' (reverse) (SEQ ID NO:19).

The positive  $\lambda$ -clone was subcloned as SacI fragments into pGEM 3Z vector (Promega) and was found to carry the 5'-region of the gene. The remaining parts of the human VEGF-B  
10 gene were amplified by PCR using genomic DNA as the template. Different combinations of primers derived from the human cDNA sequence were used. Dynazyme DNA polymerase (2.5 U/reaction, Finnzymes) was used. The amplified PCR fragments were directly cloned into the TA-cloning vector  
15 pCR II (Invitrogen Inc.). The exon-intron boundaries and the length of the short introns of the mouse and human VEGF-B genes were determined by nucleotide sequence analysis using vector specific primers or suitable primers derived from the cDNA sequences. The length of the larger introns  
20 were calculated based on the length of the amplified PCR fragments when analyzed by agarose gel electrophoresis.

#### Results.

The results showed that the coding parts of the mouse and human VEGF-B genes span approximately 4 kb of DNA and  
25 both genes are divided into seven coding exons ranging from 19 bp (E7) to 236 bp in length (E6). Figure 17 is a schematic representation of the structures of the mouse and human genes for VEGF-B. The exon sizes in base pairs are noted inside the boxes, and the sizes of the introns are  
30 noted between the boxes. The introns are not shown to scale. The structures of the untranslated flanking regions of mouse and human VEGF-B genes were not established and are represented by gray boxes. The exon-intron junctions in both genes are listed in the following Table 3:

Table 3

Exon Length	Donor Site	Intron Length (bp)	Acceptor Site
Mouse			
E1 60	T CGC ACC CAG/gtacgtgcgt a Arg Thr Gln	~590	tttcccacag/GCC CCT GTG T Ala Pro Val S
E2 43	CAG AAG AAA G/gtaataatag Gln Lys Lys V	287	ctgcccacag/TG GTG CCA TG al Val Pro Tr
E3 197	C CGA ATG CAG/gtaccagggc l Arg Met Gln	161	ctgagcacag/ATC CTC ATG A Ile Leu Met I
E4 74	GT GAA TGC AG/gtgccagcca ys Glu Cys Ar	178	ctcctcctag/G GTT GCC ATA g Val Ala Ile
mVEGF-B <sub>126</sub>			
E5 36	AG CCA GAC AG/gtgagttttt ys Pro Asp Ar	~200	ctcctcctag/G GTT GCC ATA g Val Ala Ile
E6A 211	Stop codon in exon 6 (TAG)	---	-----
mVEGF-B <sub>167</sub>			
E5 36	AG CCA GAC AG/gtgagttttt ys Pro Asp Se	~300	cccactccag/C CCC AGG ATA r Pro Arg Ile
E6B 135	AC ACC TGT AG/gtaaggagtc sp Thr Cys Ar	~2.6 kb	cactccccag/G TGC CGG AAG g Cys Arg Lys
E7 19	Stop codon in exon 7 (TGA)	---	-----
Human			
E1 60	C CCC GCC CAG/gtacgtgcgg a Pro Ala Gln	~760	tctcccacag/GCC CCT GTC T Ala Pro Val S
E2 43	CAG AGG AAA G/gtaataactta Gln Arg Lys V	275	ctgctcccag/TG GTG TCA TG al Val Ser Tr
E3 197	C CGG ATG CAG/gtactgggca l Arg Met Gln	244	ctgagcacag/ATC CTC ATG A Ile Leu Met I
E4 74	GT GAA TGC AG/gtgccagcca ys Glu Cys Ar	~710	tacttttcag/A CCT AAA AAA g Pro Lys Lys
hVEGF-B <sub>126</sub>			
E5 35	AG CCA GAC AG/gtgagtcttt ys Pro glu Ar	200	tcctccctag/G GCT GCC ACT g Ala Ala Thr
E6A 211	Stop codon in exon 6 (TAG)	---	-----
hVEGF-B <sub>167</sub>			
E5 36	AG CCA GAC AG/gtgagtcttt ys Pro Glu Se	~300	cccactccag/C CCC AGG CCC r Pro Arg Pro
E6B 135	AC ACC TGC AG/gtaggtttgg sp Thr Cys Ar	736	ccctcctcag/G TGC CGG AAG g Cys Arg Lys
E7 19	Stop codon in exon 7 (TGA)	---	-----

As previously stated, exon 6 contains an alternative splice acceptor site which enables the gene to produce two different transcripts for VEGF-B isoforms. VEGF-B<sub>167</sub> uses exons 1-5, the last part of exon 6, and exon 7 (TGA). VEGF-B<sub>186</sub> uses exons 1 through 5, the first part of exon 6, and terminates in the last part of exon 6 (TAG). Exon 7 is not translated in VEGF-B<sub>186</sub> since the insertion of the first part of exon 6 introduces a frame shift and gives rise to a stop codon in the last part of exon 6. The position of the stop codon (TAG) for VEGF-B<sub>186</sub> is marked in exon 6B, and the stop codon (TGA) for VEGF-B<sub>167</sub> is marked in exon 7.

The introns in both genes vary from 161 bp to approximately 2.6 kb. The length of each exon and the locations of the splice junctions in the two genes were identical, and all splice donor and acceptor sites follow the canonical GT/AG rules, Padgett et al., *Annual Rev. of Biochemistry*, 55:1119-50 (1986). The only notable difference between the mouse and the human genes are the length of introns 1, 4 and 6 which are longer in the mouse gene. All exon-intron boundaries were found to be conserved between VEGF-B and VEGF, but the introns in the VEGF-B genes were generally smaller than in the VEGF gene.

The 300 bp-intron after the exon 5 in VEGF-B differs from the corresponding one in VEGF, which is 3 kb in length and contains an alternatively spliced exon found in the transcripts for VEGF<sub>189</sub> and VEGF<sub>206</sub>, encoding many basic amino acid residues. When this intron in VEGF-B was analyzed more carefully, no exon corresponding to the 6th exon of VEGF could be found. Instead, the 3' end of this intron and the following exon were found to be identical with the corresponding sequences of the cDNA clones encoding VEGF-B<sub>186</sub>. This is explainable by the fact that the mRNA for VEGF-B<sub>186</sub> is formed by use of an alternative splice acceptor site during mRNA splicing, resulting in an insertion of a 101 bp intron sequence into these mRNAs.

Figure 18 shows a comparative hydrophilicity analysis of murine VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub>. The profiles were generated according to Kyle and Dolittle using a window of nine (9) residues. As would be expected, the pattern of hydrophilicity/hydrophobicity is essentially identical from amino acid 1 through amino acid 115. After amino acid 115, the hydrophilicity/hydrophobicity patterns diverge because of the frame shift introduced by the first part of exon 6. Thus, VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> can be expected to exhibit both similar and dissimilar activities.

Figure 19 is a dendrogram showing the phylogenetic relationship of the amino acid sequences of five members of the VEGF/PDGF family of growth factors. The number of replacements or substitutions decreases from the left to the right of the chart. It can be seen that VEGF-B lies between VEGF and the platelet derived growth factor (PDGF) group.

The multiple amino acid sequence alignments of Figures 9 and 16 and the phylogenetic analysis of Figure 19 were carried out according to Hein, *Methods in Enzymology*, Vol. 183, pp. 626-45, Academic Press Inc., San Diego (1990) using the PAM 250 distance table.

#### Example 8: Antibody Production.

##### a. Antiserum to Mouse VEGF-B.

Antisera to mouse VEGF-B were raised by immunizing rabbits with a 18-mer oligopeptide comprising the N-terminal region of processed VEGF-B, coupled to keyhole limpet hemocyanin. Cysteine residues were introduced as the N-terminal and C-terminal amino acid residues to allow coupling of the peptide to the carrier protein using SPDP (Pharmacia). The sequence of the oligopeptide was

C-P-V-S-Q-F-D-G-P-S-H-Q-K-K-V-V-P-C (SEQ ID NO:21).

Each rabbit received a subcutaneous injection with 300 µg of the peptide conjugate emulsified in Complete Freund's Adjuvant. Subcutaneous booster injections were given every second week with the same amount of antigen emulsified in

Incomplete Freund's Adjuvant. Sera were obtained after the second booster injections.

b. Antiserum to Human VEGF-B.

Antipeptide antiserum to human VEGF-B was generated by immunizing rabbits with a branched 23-mer oligopeptide comprising the following N-terminal region amino acid residue sequence (SEQ ID NO:22):

S-Q-P-D-A-P-G-H-Q-R-K-V-V-S-W-I-D-V-Y-T-R-A-T.

The branched 23-mer oligo peptide was synthesized according to Tam, "Synthetic peptide vaccine design: synthesis and properties of a high-density multiple antigenic peptide system", *Proc. Natl. Acad. Sci. USA*, Vol. 85, pages 5409-413 (1988). In the first immunization, rabbits were subcutaneously injected with 500 µg of the branched peptide emulsified in Complete Freund's Adjuvant. In the subsequent boosters, 200 µg of the antigen emulsified in Incomplete Freund's Adjuvant was injected. Antisera were collected after the second and third boosters by conventional techniques.

20

Example 9: Biochemical properties of VEGF-B<sub>167</sub>, homo-dimerization, and heterodimerization with VEGF.

The biochemical properties of human VEGF-B<sub>167</sub> were examined in transfected human embryonic kidney 293EBNA cells (Invitrogen, Inc.). cDNA inserts encoding human VEGF-B<sub>167</sub> and human VEGF<sub>165</sub> [see Keck et al., *Science*, Vol. 246, pages 1309-312 (1989)] were individually cloned into the pREP7 expression vector (Invitrogen, Inc.). Human embryo kidney 293EBNA cells (expressing Epstein-Barr virus nuclear antigen-1) were transfected by transient transfection with the respective expression plasmids using calcium phosphate precipitation, and the cells were incubated for 48 hours. As a control, cells also were transfected with an expression vector containing the VEGF-B<sub>167</sub> cDNA in reverse orientation. Monolayers of cells were incubated in methionine-free and cysteine-free medium for 30 minutes followed by labeling

with 100  $\mu$ Ci/ml [ $^{35}$ S]methionine and [ $^{35}$ S]cysteine (Promix, Amersham Inc.) in the same medium for 2 hours. The labeling medium was replaced with normal medium without serum, and labelled proteins were chased for 6 hours. Heparin was  
5 included during the chase when indicated (100  $\mu$ g/ml). Media were collected after the chase period, and cells were solubilized in 10 mM Tris pH 7.5, 50 mM NaCl, 0.5% sodium deoxycholate, 0.5% Nonidet P-40, 0.1% SDS and 0.1 U/ml aprotinin.

10 VEGF-B<sub>167</sub> was expressed in the cells transfected with the plasmids containing the VEGF-B<sub>167</sub> DNA. Aliquots of the culture supernatants from cells treated or untreated with heparin and detergent solubilized cell lysates were subjected to immunoprecipitation with the specific  
15 antipeptide antiserum to VEGF-B obtained as described in Example 8 and analyzed by SDS-PAGE under reducing conditions unless otherwise indicated. The data show that VEGF-B<sub>167</sub> homodimers and VEGF-B<sub>167</sub> - VEGF<sub>165</sub> heterodimers are released from cells by heparin. By heparin treatment (1-100  $\mu$ g/ml)  
20 or 1.2 M NaCl, VEGF-B<sub>167</sub> was released from cells and found in the supernatant. If cells were not treated with heparin, VEGF-B<sub>167</sub> remained cell-associated and was not released into the culture medium. Under the same conditions, VEGF<sub>165</sub> homodimers are secreted from the cells and found in the  
25 culture supernatants without heparin treatment.

Under reducing conditions, human VEGF-B<sub>167</sub> migrated with a Mr of 21 kDa. Analysis of culture supernatants under non-reducing conditions showed that VEGF-B<sub>167</sub> migrated as an  
30 Mr 42 kDa species indicating a dimeric structure. These results suggest that VEGF-B<sub>167</sub> forms disulfide-linked dimers associated with the cell surface, probably through ionic interactions with extracellular heparan sulfate proteoglycans. The association is likely to be mediated by  
35 the C-terminal basic domain, as observed for the longer splice variants of VEGF.

Since VEGF has been shown to form heterodimers with PlGF, it was decided to test whether VEGF<sub>165</sub> could also form heterodimers with VEGF-B<sub>167</sub>. For this purpose 293EBNA cells were co-transfected with expression vectors encoding both human VEGF<sub>165</sub> and human VEGF-B<sub>167</sub>, and VEGF-B<sub>167</sub> was expressed in combination with VEGF<sub>165</sub>. Metabolically labelled proteins were chased in the presence of heparin, and immunoprecipitations were carried out with antisera to either VEGF-B<sub>167</sub> or VEGF<sub>165</sub>. The antiserum to human VEGF was from R&D Systems. Under non-reducing conditions the VEGF-B<sub>167</sub>-VEGF<sub>165</sub> heterodimers migrated as Mr 42-46 kDa species. The results show that VEGF-B can form disulfide linked heterodimers with VEGF, which, in the absence of heparin, remain cell-associated. Since homodimers of VEGF<sub>165</sub> are efficiently secreted into the media, VEGF-B appears to determine the secretion of the heterodimer.

VEGF-B is synthesized normally in the endoplasmic reticulum of the source cell for subsequent export. Recombinant VEGF-B may be produced by inserting a DNA sequence encoding the VEGF-B protein together with suitable operatively linked promoter and control sequences into a suitable vector, such as the well known plasmid pBR322 or a derivative thereof, transforming or transfecting a suitable host cell, such as *E. coli* or a Cos cell, with the resulting vector or other systems well known in the art, screening the resulting transformants or transfectants for VEGF-B expression, and then culturing cell lines or bacterial cell strains which are positive for the expression of VEGF-B. Either a eukaryotic vector or a prokaryotic vector may be used, depending on the type of cell which is to be transfected or transformed therewith. A particularly preferred system for production of recombinant VEGF-B is the baculovirus - insect cell system, which has proved capable of producing excellent yields of recombinant protein.

Example 10: VEGF-B expression using the baculovirus system.

10.1 VEGF-B with its own signal peptide.

a) Cloning and Transfection.

The complete human VEGF-B<sub>167</sub> gene was inserted into a commercially available plasmid pCRII (Invitrogen Corp.). The HindIII-XbaI fragment from the resulting plasmid pCRII-VEGF-B<sub>167</sub>, which encodes the whole open reading frame of VEGF-B<sub>167</sub>, then was cloned into pFASTBAC1, and both the 3'- and 5'-junctions were sequenced. Bacmid-DNA was prepared according to the manufacturers instructions for the "Bac-To-Bac™ Baculovirus Expression System" (Life Technologies Inc.) and lipofected to Sf900II-adapted Sf9 cells (obtained from Dr. Christian Oker-Blom). Sf9 cells are from the American Type Culture Collection Cell Repository Line Bank, Rockville MD (ATCC CRL-1711). The transfected cells were then cultured on standard TMN-FH medium in 25 cm<sup>2</sup> culture dishes.

b) Assay for protein expression.

About 72 hours after transfection, the cells were lysed and 1 ml of culture supernatant and the cell lysate were assayed for expressed VEGF-B by immunoprecipitation as described in Example 9 and Western blotting. Lysates from three out of four independently transfected cell cultures were found positive for VEGF-B, although the intensity of the signal in the Western blot varied. The expressed VEGF-B polypeptide in each case was found to correspond in size to the protein expressed in mammalian cells in Example 9.

The viral stock from the cells that gave the strongest signal in Western blotting was amplified two rounds by infecting cells and collecting new virus from the medium. The resulting supernatant was analyzed. Uninfected cells were also analyzed as a negative control. Time course analysis showed that cells harvested between 48 and 72 hours after infection contained the greatest amount of VEGF-B. After 96 hours post infection, as a result of virus-induced cell lysis, VEGF-B could also be detected in the culture supernatant by immunoprecipitation and Western blotting.

Recombinant VEGF-B could be precipitated from the lysate between 20% and 40%  $(\text{NH}_4)_2\text{SO}_4$ .

#### 10.2 VEGF-B with the Melittin signal peptide (pVTBac).

##### a) Cloning and transfection.

5       A polymerase chain reaction (PCR) fragment from nucleotide position 68 to 141 was used to introduce a BamHI restriction site immediately after the signal cleavage site in the plasmid pCRII-VEGF-B<sub>167</sub> from Example 10.1. The BamHI fragment from this modified pCRII-VEGF-B<sub>167</sub> construct was  
10       cloned into BamHI opened pVTBac [Tessier et al., "Enhanced secretion from insect cells of a foreign protein fused to the honeybee mellitin signal peptide", *Gene*, Vol. 98, page 177 (1991)]. Both 3'- and 5'-junctions were sequenced. Sf9 cells were cotransfected with the aforescribed pVTBac  
15       vector which contained the human VEGF-B<sub>167</sub> gene, and with linearized baculovirus DNA (Insectin™, Invitrogen Corp.). The transfected cells then were cultured in TMN-FH medium.  
b) Assay for protein expression.

Forty-eight hours after transfection, the supernatant  
20       was collected and subjected to primary screening by immunoprecipitation. Four positive plaques were isolated.

10.3 A cDNA insert encoding murine VEGF-B<sub>186</sub> (EcoRI cut cDNA fragment from a murine VEGF-B<sub>186</sub> cDNA (SEQ ID NO:12) clone) was cloned into pFASTBAC 1. An EcoRI cut cDNA  
25       fragment from murine VEGF-B<sub>167</sub> (SEQ ID NO:4) was also cloned into pFASTBAC 1. The resulting plasmids were transformed into bacteria as described in 10.1 above, and recombined plasmids were isolated and lipofected into Sf9 and Sf21 cells. Supernatants containing recombinant baculovirus were  
30       amplified by several rounds of reinfection of Sf21 cells. The final titers of the baculovirus stocks were determined by plaque titration and found to vary between  $4 \times 10^6$  and  $2 \times 10^9$  baculovirus particles per milliliter of stock supernatant.

Example 11: Large Scale Production of Recombinant VEGF-B.

Sf21 cells [see Vaughn et al., *In Vitro*, 13:213-17 (1977)] were infected with the baculovirus stocks of Example 10 at a multiplicity of infection of 10 virus particles per cell. The infected Sf21 cells were grown in roller flasks and seeded at a density of  $2 \times 10^6$  cells per ml of serum free medium (Sf900II, Gibco-BRL) for 96 hours. Culture media and cells were then harvested. Aliquots of the cell lysates and of the media were analyzed by SDS-PAGE. Total protein patterns were visualized by staining the gels with Coomassie Brilliant Blue and the presence of expressed VEGF-B isoforms were visualized by immunoblotting using specific antipeptide antibodies to human and mouse VEGF-B as described above in Example 8. The analysis revealed that both human and mouse VEGF-B<sub>167</sub> polypeptides were of the expected sizes of 21.5 kDa. Both proteins were retained intracellularly in the infected cells and not released into the medium. In contrast, mouse VEGF-B<sub>186</sub> was readily secreted into the medium in a dimeric form. The VEGF-B<sub>186</sub> homodimers migrated as a 52-54 kDa species which suggested that insect cell produced protein did not undergo the same covalent modification as found for VEGF-B<sub>186</sub> secreted from transfected Cos-1 cells.

Example 12: Transfection and analysis of Cos-1 cells expressing VEGF-B<sub>186</sub>.

cDNA inserts encoding mouse VEGF-B<sub>186</sub> and human VEGF<sub>165</sub> were cloned into the pSG5 expression vector [Green et al., *Nucleic Acid Res.*, 16:369 (1988)]. Cos-1 cells were maintained in minimal essential medium (MEM) containing 10% fetal calf serum, 2mM glutamine and appropriate antibiotics. For transfections, the cells were replated into 90 mm Petri dishes. The cells were transfected with the expression vectors, separately or in combination, using calcium phosphate precipitation and incubated for 36-48 hours. Monolayers of cells were incubated in medium free of methionine and cysteine for 30 min and then incubated in the

same medium containing 100  $\mu$ Ci/ml of [ $^{35}$ S]-methionine and [ $^{35}$ S]-cysteine for 2 hours (Promix Amersham Inc.).

For the pulse-chase experiments, the cells were labeled for 30 minutes, washed twice with normal medium and then incubated for up to 6 hours in MEM without fetal calf serum. Media were collected after the chase period and the cells were solubilized in 10 mM Tris buffer pH 7.5 containing 50 mM NaCl, 0.5% deoxycholate, 0.5% nonidet P-40 and 0.1% SDS. Aliquots of the media and the cell lysates were subjected to immunoprecipitation using the specific antiserum to mouse VEGF-B from Example 8a and a specific antiserum to human VEGF commercially available from R&D Systems. The precipitates were analyzed by SDS-PAGE.

Example 13: Biochemical properties of VEGF-B<sub>186</sub> expressed in transfected Cos-1 cells.

The biochemical properties of mouse VEGF-B<sub>186</sub> were examined in Cos-1 cells transiently transfected as described in Example 12 with an appropriate expression vector. The cells were metabolically labelled, and proteins from the labelled cells were immunoprecipitated using an antipeptide antibody to VEGF-B. The precipitated material was subjected to SDS-PAGE analysis under reducing conditions. Both the cell culture medium (M) and a detergent solubilized cell lysate (L) were analyzed. The results are shown in Figure 22. It can be seen that cell associated VEGF-B<sub>186</sub> migrated as an approximately M<sub>r</sub> 24,000 polypeptide under reducing conditions. In contrast, VEGF-B<sub>186</sub> present in the medium of transfected cells migrated as a M<sub>r</sub> 32,000 species, suggesting that the protein was covalently modified during its intracellular transport and secretion. The corresponding molecules were not detected in cell lysates or media from mock transfected Cos-1 cells used as a control.

Immunoprecipitation of media and SDS-PAGE analysis under non-reducing conditions, showed an approximately M<sub>r</sub> 60,000 species suggesting that VEGF-B<sub>186</sub> formed disulfide-

linked homodimers. Including 100 ug/ml of heparin during the labelling did not affect the secretion or release of VEGF-B<sub>186</sub> homodimers from the transfected cells.

5 Example 14: Biosynthesis of VEGF-B<sub>186</sub> homodimers.

The biosynthesis of VEGF-B<sub>186</sub> homodimers was examined by pulse-chase experiments. Transfected Cos-1 cells were metabolically labelled for 30 minutes and then chased for up to 4 hours. Immunoprecipitation and SDS-PAGE analysis of  
10 detergent solubilized cell lysates and media showed that the cell-associated approximately M<sub>r</sub> 24,000 species was readily detected in the lysates throughout the chase period. The decrease in the intensity of this molecular species was associated with an increase in the M<sub>r</sub> 32,000 protein present  
15 in the media. The M<sub>r</sub> 32,000 species appeared in the medium after 1 hour of chase. Highest levels of secreted VEGF-B<sub>186</sub> were obtained after the 4 hour chase period. No intermediates were detected in the cell lysates, but the secreted M<sub>r</sub> 32,000 protein appeared slightly heterogenous.  
20 The nature of the modification is presently unknown, but N-linked glycosylation can be excluded in the absence of consensus sites for this modification.

Example 15: Formation of heterodimers by VEGF-B<sub>186</sub>.

25 As noted above, VEGF-B and VEGF are coexpressed in many tissues and VEGF-B<sub>167</sub>·VEGF<sub>165</sub> heterodimers are readily formed when coexpressed in transfected cells. To examine whether VEGF-B<sub>186</sub> also could form heterodimers with VEGF<sub>165</sub>, Cos-1 cells were transfected as described above with the  
30 appropriate expression vectors, either alone or in combination. Metabolically labelled proteins present in the media from the transfected cells were subjected to immunoprecipitations using antisera to VEGF-B and VEGF. Figure 23A shows the results of SDS-PAGE analysis under  
35 reducing conditions of the immunoprecipitates from the cell culture media of transiently transfected Cos-1 cells

separately expressing VEGF-B<sub>186</sub> and VEGF, respectively. It can be seen that the antisera were specific for VEGF-B and VEGF, respectively, with no detectable cross-reactivity.

Cos-1 cells were cotransfected with expression vectors  
5 for VEGF-B<sub>186</sub> and VEGF<sub>165</sub>. Cell culture media (M) and detergent solubilized lysates (L) from the resulting cells which coexpressed VEGF-B<sub>186</sub> and VEGF<sub>165</sub> were subjected to immunoprecipitation and SDS-PAGE analysis under reducing conditions. The results are shown in Figure 23B. The test  
10 showed that murine VEGF-B<sub>186</sub> and human VEGF<sub>165</sub> form intracellular and secreted heterodimers.

Culture media from cells expressing murine VEGF-B<sub>186</sub> and human VEGF<sub>165</sub>, either separately or in combination, were subjected to immunoprecipitation using antibodies to VEGF-B  
15 and VEGF and analyzed by SDS-PAGE under non-reducing conditions. As a control, cell culture medium from mock transfected cells was analyzed. The results are shown in Figure 23C. It was found that VEGF-B<sub>186</sub> forms secreted disulfide-linked homodimers and that VEGF-B<sub>186</sub> and VEGF<sub>165</sub>  
20 together form secreted disulfide-linked heterodimers.

To analyze whether heterodimer formation with VEGF affected the secretion and release of VEGF-B<sub>186</sub>, pulse-chase experiments were carried out using Cos-1 cells transiently transfected with expression vectors for VEGF-B<sub>186</sub> and VEGF<sub>165</sub>.  
25 Cell associated disulfide-linked heterodimers could be recovered following the 30 minute labelling period, and secreted heterodimers were recovered from the medium already after a 30 minute chase period. The secreted heterodimers accumulated in the medium for up to 2 hours post labelling.  
30 In the 4 hour chase time point there was a decrease in the amount of heterodimers in the medium, possibly due to the degradation of the complex. Some VEGF-B<sub>186</sub>·VEGF heterodimers remained cell-associated throughout the chase. These results suggested that heterodimer formation with VEGF  
35 promoted the secretion of VEGF-B<sub>186</sub> compared to the secretion of VEGF-B<sub>186</sub> homodimers. Furthermore, the presence of

heterodimers already following the 30 minute labelling period suggested that the slow release of VEGF-B<sub>186</sub> homodimers was not due an impaired ability of VEGF-B<sub>186</sub> to dimerize.

5    Example 16: Purification of Secreted VEGF-B<sub>186</sub> Homodimers.

Secreted VEGF-B<sub>186</sub> homodimers were isolated from serum free culture media of baculovirus infected Sf21 cells as follows:

10        a. Initial Separation.

10        The major contaminating protein in the culture media was the baculovirus protein gp64/67, an acidic protein secreted by baculovirus infected cells. To remove this protein, the culture media was concentrated twenty-fold by ultrafiltration and then passed over a Sephadex G-25 column  
15        equilibrated in 20 mM phosphate buffer pH 6.5 containing 20 mM NaCl. Eluted proteins were then passed over a CM-Sepharose (Pharmacia) ion-exchange column equilibrated in the same buffer. The column was washed with the phosphate buffer to remove unbound proteins, and bound proteins were  
20        eluted by stepwise increasing the NaCl concentration of the elution buffer. The major gp64/67 baculovirus encoded protein did not bind to the ion-exchange column under those conditions while VEGF-B<sub>186</sub> homodimers eluted at a NaCl concentration of 90 mM. As judged by SDS-PAGE analysis of  
25        the eluted fraction, VEGF-B<sub>186</sub> homodimers were 5-15% pure by this procedure.

         b. Purification to Homogeneity.

         The VEGF-B<sub>186</sub> homodimers are purified to homogeneity on a MonoS column coupled to a FLPC system (Pharmacia). Bound  
30        protein is eluted with a linear gradient of NaCl in 20 mM phosphate buffer pH 6.5.

Example 17:

         In order to find out whether the two VEGF-B splice  
35        isoforms exhibited a differential tissue distribution and whether additional isoforms existed, an RT-PCR analysis was

carried out using total RNA extracted from mouse brain, heart, liver and kidney and from human embryonic heart and skeletal muscle. The transcripts were analyzed by PCR using four pairs of specific primers covering exons 4 to 7 and  
5 exons 3 to 7 in the mouse and human VEGF-B genes, respectively.

Procedure.

Total RNA from mouse and human tissues were isolated using standard procedures as disclosed by Chirgwin et al.,  
10 *Biochemistry*, 18:5294-99 (1979). Two to five  $\mu$ g of total RNA per reaction were used for first strand cDNA synthesis using avian myeloblastosis virus reverse transcriptase (20 U/reaction). The reactions were primed with oligo-(dT)<sub>18</sub>. Aliquots of these reactions were used as templates in PCR  
15 reactions using Taq DNA polymerase (2.5 U/reaction). To amplify mouse cDNA, two pairs of primers were used. These pairs were obtained by combining a common 5'-primer  
5'-CACAGCCAATGTGAATGCA (forward) (SEQ ID NO:23), located in exon 4 with two different 3'-primers  
20 5'-GCTCTAAGCCCCGCCCTTGGCAATGGAGGAA (reverse) (SEQ ID NO:24), and 5'-ACGTAGATCTTCACTTTCGCGGCTTCCG (reverse) (SEQ ID NO:25). (this last primer has a Bgl II site and 4 extra bases in the 5' end) located in exons 6B and 7, respectively. Following analysis by agarose gel electrophoresis, the amplified bands  
25 were transferred onto a nylon filter (Genescreen Plus) and sequentially hybridized with oligonucleotide probes specific for exons 6A and 6B. The oligonucleotide probes were 5'-CTCTGTTCCGGGCTGGGACTCTA (exon 6A) (SEQ ID NO:26) and 5'-TCAGGGCGTTGACGGCGCTGGGTGCAA (exon 6B) (SEQ ID NO:27).  
30 The oligonucleotide probes were labeled with [<sup>32</sup>P]dCTP using terminal transferase to high specific activity. Hybridizations, using 1 x 10<sup>6</sup> cpm of labeled probe/ml of solution, were carried out at 37° C in 6 x SSC containing 5 X Denhardt's solution, 0.5% SDS and 100  $\mu$ g/ml of salmon  
35 sperm DNA. The filters were washed at the same temperature

in 6 x SSC containing 0.5% SDS for 2 x 15 min and exposed to film.

The two pairs of primers used for amplification of human cDNA were combined using two different 5'-primers,

5 5'-CCTGACGATGGCCTGGAGTGT (forward) (SEQ ID NO:28),  
located in exon 3 and

5'-TGTCCTGGAAGAACACAGCC (forward) (SEQ ID NO:29),  
located in exon 4, with a common 3'-primer,

5'-GCCATGTGTACCTTCGCAG (reverse) (SEQ ID NO:19)  
10 located in exon 7. Aliquots of the amplified products were  
analyzed by agarose gel electrophoresis. The aliquots were  
directly cloned in the TA-cloning vector pCR II (Invitrogen,  
Inc.), and generated plasmids were analyzed by nucleotide  
sequencing. Amplification of GAPDH served as a control.

15 Results.

Analysis of amplified PCR products by agarose gel  
electrophoresis showed two major bands of 215 and 316 bp,  
respectively. These sizes are consistent with the two mRNAs  
corresponding to VEGF-B<sub>16</sub> and VEGF-B<sub>186</sub>. These two bands were  
20 of the same intensity suggesting that the two isoforms were  
expressed at approximately equal levels in all mouse and  
human tissues examined.

To verify the identity of the amplified products from  
mouse tissues, the PCR-amplified DNA was transferred to a  
25 filter and probed with specific oligonucleotide probes for  
exons 6A and 6B, respectively. The autoradiograms showed  
that an exon 6-specific probe hybridized with the 316 bp  
band while the exon 6B specific probe hybridized with both  
the 215 bp and the 316 bp amplified bands. These results  
30 are consistent with the alternative usage of acceptor site  
in exon 6 to create the two isoforms of VEGF-B and thus all  
the amplified products corresponded to those predicted from  
the sequences of VEGF-B<sub>16</sub> and VEGF-B<sub>186</sub> isoforms.

Agarose gel electrophoresis of products of PCR analysis  
35 of total RNA isolated from human embryonic heart and muscle  
visualized two major amplified bands of 329 bp and 430 bp.

Taken together, these data demonstrate that VEGF-B<sub>167</sub> and VEGF-B<sub>186</sub> are the two major isoforms of VEGF-B in tissues. The pattern of the PCR products and the location of the primers indicate that if any still longer splice isoforms exist for VEGF-B, such transcripts use a splice acceptor site located a little more 5' than in the case of VEGF-B<sub>186</sub>. Furthermore, PCR products corresponding to VEGF<sub>121</sub>, which lacks heparin binding domains, i.e. sequences corresponding to exon 6 in VEGF-B, were not detected. However, splicing of exon 5 to exon 7 would give rise to a transcript encoding an isoform of VEGF-B corresponding to VEGF<sub>121</sub>, and this putative isoform of VEGF-B might be expressed in tissues other than those analyzed in this example.

Example 18: Stimulation of Cell Proliferation.

The ability of VEGF-B<sub>167</sub> to stimulate endothelial cell proliferation was established through analysis of [<sup>3</sup>H]thymidine incorporation in human umbilical vein endothelial cells (HUVEC) and in bovine capillary endothelial (BCE) cells.

293EBNA cells were transfected as described above with expression vectors for VEGF-B<sub>167</sub>, VEGF<sub>165</sub> or empty vector (mock) in the presence of 1 µg/ml heparin. Conditioned media from these cells were diluted in respective media, applied to human umbilical vein endothelial cells (HUVEC) and to bovine capillary endothelial (BCE) cells and incorporation of [<sup>3</sup>H]thymidine was measured. As a positive control recombinant bFGF was added to BCE cells.

To elaborate, conditioned media containing human VEGF-B and human VEGF<sub>165</sub> were collected from 293EBNA cells transfected with the appropriate expression vectors or with empty vector (mock) in the presence of heparin (1 µg/ml) 48 hours posttransfection. Second passage HUVEC were plated into 96-well plates (4 x 10<sup>3</sup> cells/well) in M-199 medium supplemented with 10% fetal bovine serum and incubated for 24 hours. Conditioned media were diluted with the growth

medium, and cells were stimulated for 48 hours. Fresh conditioned media containing 10  $\mu\text{Ci/ml}$  of [ $^3\text{H}$ ]thymidine (Amersham Inc.) were added to the cells, and stimulations were continued for another 48 hours. Cells were washed with  
5 PBS and trypsinized, and incorporated radioactivity was determined by liquid scintillation counting. BCE cells were seeded into 24-well plates and grown until confluence in minimal essential medium (MEM) supplemented with 10% fetal calf serum. Cells were starved in MEM supplemented with 3%  
10 fetal calf serum for 72 hours, after which conditioned media diluted into serum-free medium were added to the cells and the cells were stimulated for 24 hours. [ $^3\text{H}$ ]Thymidine was included during the last 4 hours of the stimulation (1  $\mu\text{Ci/ml}$ ). Stimulations with bFGF were carried out as above  
15 using 6 ng/ml of recombinant bFGF (Synergen Inc.). Cells were washed with PBS, lysed with NaOH, and incorporated radioactivity was determined by liquid scintillation counting.

Figure 20 is a bar graph showing fold of induction of  
20 [ $^3\text{H}$ ]thymidine incorporation by VEGF-B<sub>167</sub> in human umbilical vein endothelial cells (HUVEC) and in bovine capillary endothelial (BCE) cells, as compared to basal activity induced by conditioned medium from the mock transfected cells. For comparison purposes, the induction by VEGF<sub>165</sub> and  
25 by bFGF are also shown. The bars show the mean  $\pm$  standard deviation of parallel samples. Similar results were obtained in several other independent experiments. The test results clearly show that VEGF-B induced [ $^3\text{H}$ ]thymidine  
30 incorporation in both HUVEC and BCE cells and stimulated proliferation of endothelial cells in vitro, thereby demonstrating that VEGF-B is an endothelial growth factor.

Example 19: Identification of human VEGF-B promoter DNA clones and activity.

35 A human genomic DNA library in bacteriophage  $\lambda$  EMBL was screened using a 5' PCR fragment containing the sequences

from the VEGF-B first and second exons as a probe. Two positive clones were obtained, and one of these was subcloned in the Bluescript SKII plasmid as Sac I fragments. A 1.4 kb fragment was obtained, which contained about 0.4 kb of sequences upstream from an Nco I site present in the cDNA (located less than 100 bp upstream of the ATG translational initiation site).

In addition, an XhoI fragment of about 6 kb from the other  $\lambda$  clone was subcloned into the pGEMEX plasmid. This subclone contained about 1.5 kb of sequences upstream from the NcoI site. The SacI/NcoI fragment and an EcoRI (polylinker) - NcoI fragment were subcloned into pGL3 basic vector (Promega) in the respective transcriptional orientation. DNA of these subclones, and from the pGL3 control vector containing the SV40 promoter, was transfected into HeLa cells using calcium phosphate precipitation. Two days after transfection, the luciferase activities were measured from lysates of the transfected cells. The results indicated that the 400 bp SacI/NcoI fragment has promoter activity equal to about 30% of the activity of the pGL3 control vector, while the 1.5 kb fragment gave only background activity. Use of a stronger or more active promoter, for example the CMV promoter or the elongation factor 1-alpha promoter, would probably give higher activity in human cells and tissues. The structure of the cloned fragments is illustrated in Figure 24.

The 1.5 kb fragment upstream of the Nco I site was sequenced. The resulting sequence (SEQ ID NO:17) is illustrated in Figure 25. The sequence obtained revealed a putative silencer element [Weissman and Singer, *Molecular and Cellular Biology*, 11:4228-234 (1991)] composed of two eight-base pair stretches between nucleotides 166-187 (boxed in the drawing). This silencer may be responsible for the relative lack of activity of the 1.5 kb fragment.

Example 20: Analysis of VEGF-B mRNA in melanomas, normal skin and muscle by RT-PCR.

Normal skin and melanoma tissues were obtained from patients attending the Department of Radiotherapy and Oncology, Helsinki University Central Hospital. Four metastatic melanoma specimens were obtained freshly after surgical excision, immediately embedded in Tissue-tek (Miles) and frozen in liquid nitrogen. Samples of normal skin were obtained from volunteer patients undergoing surgery for mammary carcinoma and excision of a cutaneous naevus. All specimens were inspected by a pathologist to confirm the diagnosis.

Total RNA was isolated by the guanidium isothiocyanate procedure [Chomczynski et al., *Anal. Biochem.* 162:156-159 (1987)]. cDNA was synthesized using 0.2 µg of random hexadeoxynucleotide primers, 5 units of murine reverse transcriptase, 5 µg of total RNA as a template and a first-strand cDNA synthesis kit (Pharmacia). After incubation at 37°C for 1 hour, the reaction mixture was stored at -70°C. Negative control samples for PCR amplification were prepared similarly except that reverse transcriptase was not added. β-actin also was tested as an internal standard because it is expressed at a constitutive high level, and its expression does not show much variation in different cells.

For PCR amplification, the primer sequences were selected from the VEGF-B and β-actin genes as follows:  
VEGF-B sense: 5'-GCCATGTGTCACCTTCGCAG-3' (SEQ ID NO:19)  
VEGF-B antisense: 5'-TGTCCCTGGAAGAACACAGCC-3' (SEQ ID NO:29)  
β-actin sense: 5'-CGGGAAATCGTGCGTGACAT-3' (SEQ ID NO:30)  
β-actin antisense: 5'-GGAGTTGAAGGTAGTTTCGTG-3' (SEQ ID NO:31)  
[β-actin sequences comprise nucleotides 2105-2125 and 2411-2432 from Ng et al., *Mol. Cell Biol.* 5:2720-732 (1985)].  
An aliquot of 4 µl from the cDNA reaction product was heated to 94°C for 5 minutes and used as a template for PCR amplification with 20 pmol of primers, 10x PCR buffer, 1µl of 20 mM dNTPs and 2.5 U of Taq polymerase. Final volume

was adjusted to 100  $\mu$ l with DEPC treated water. Denaturation was at 95°C for 1 minute, annealing at 62°C for 45 seconds, and polymerization at 72°C for 50 seconds, for a total of 35 cycles for VEGF-B and 25 cycles for  $\beta$ -actin. 5 After every 5 cycles, 15  $\mu$ l aliquots were taken for analysis.

Electrophoresis of 5  $\mu$ l of the PCR reaction mix was performed in a 2% agarose gel containing ethidium bromide. The size marker DNA fragments ranged in length from 24 to 10 726 base pairs ( $\Phi$ X174 DNA/Hinf I marker from Promega, Madison, WI, USA). The tested samples thus included four metastatic melanomas, muscle, normal skin, a negative control (without reverse transcriptase), and the  $\Phi$ X174 DNA/Hinf I size marker. The results of the RT-PCR analysis 15 for VEGF-B (PCR product lengths 323 and 234 bp) and for  $\beta$ -actin show that VEGF-B is highly expressed in all melanomas studied, at levels approximately similar to the expression in muscle tissue. On the other hand, normal skin has very little of the VEGF-B RNA. Similar conclusions can be drawn 20 from Northern blotting and hybridization analysis.

The foregoing results indicate that that VEGF-B is a novel growth factor for endothelial cells which plays a role in vascularization, in particular of muscle. Collateral artery growth in ischemic heart or limb may be promoted by 25 arterial administration of a VEGF-B bolus using techniques described by Takeshita et al., *Am. J. Pathol.*, 147:1649-60 (1995). The cell-association of VEGF-B may have several implications for regulation of vascularization and endothelial cell growth. In developing embryos and in 30 contractile tissues, cell-associated VEGF-B may provide spatial cues to outgrowing endothelial cells during establishment and maintenance of the vascular tree. It could also, through its cell-association, support the regeneration of damaged endothelium in adult vessels. 35 Reendothelialization of arterial injury may be promoted by direct application of VEGF-B using techniques described by

Asahara et al., *Circulation*, 91(11):2793-802 (1995). The ability of VEGF-B to modulate the secretion of VEGF by heterodimer formation suggests an indirect role of VEGF-B in VEGF signalling, thereby regulating receptor binding and/or activation as described by Potgens et al., *J. Biol. Chem.*, 269(52):32879-85 (1994). The formation of multiple heterodimeric complexes of these growth factors could provide a basis for a diverse array of regulatory signals for endothelial cells.

VEGF-B can be used as a growth factor for populations of endothelial cells *in vitro*. VEGF-B may be used to promote desirable angiogenesis, i.e. the formation of new blood vessels and capillaries; see Takeshita et al., *supra*. For example, it may be useful in promoting the development of the corpus luteum and endometrium as an aid to initiating and/or maintaining pregnancy. It would also be useful in bone repair by virtue of its action on endothelial cells. Administration of VEGF-B may also be useful in supporting embryogenesis, as well as somatic growth and vascular development and differentiation. Topical application of VEGF-B to wounds may be useful in promoting wound healing, and oral administration of VEGF-B may be useful to accelerate the healing of gastric and/or duodenal ulcers. The ability of VEGF-B to modulate the secretion of VEGF by heterodimer formation could provide a therapeutic role for VEGF-B in diseases where VEGF agonists would be useful; see Potgens et al., *supra*.

VEGF-B may exert proliferative effects on mesodermal cells either directly or via improvements in the blood supply.

VEGF-B has been found to be overexpressed in tumors, such as melanomas. Consequently, assays for VEGF-B expression can be used as tools in tumor diagnosis, and suppression of VEGF-B expression, for example with monoclonal antibodies, may be useful to retard tumor growth.

Tumor assays for VEGF-B may be useful as indicators of metastatic risk. For example, use of VEGF-B antibodies analogous to the procedures described by Takahashi et al., *Cancer Res.*, 55:3964-68 (1995) in order to quantitate neovascularization and proliferation could be used as an indicator of metastatic risk from colon cancer. Assays of VEGF-B in body fluids or the tumor itself by histochemistry may be useful as a tumor prognostic factor. An ELISA analogous to the procedure described by Kondo et al., *Biochemica et Biophysica Acta*, 1221(2):211-14 (1994) may be useful to detect VEGF-B upregulation as a tumor screen. An enzyme linked immunoabsorbent assay of VEGF-B expression using techniques described by Boockock et al., *J. Natl. Cancer Inst.*, 87:506-16 (1995) may be useful as a diagnostic index of ovarian cancer. An assay of VEGF-B expression similar to the VEGF assay described by Weindel et al., *Neurosurgery*, 35:439-48 (1994) may be useful as an indicator of malignancy in brain tumors.

Furthermore, because tumor growth requires angiogenesis, administration of VEGF-B may also be useful in promoting tumor growth in laboratory animals in order to test anti-tumorigenic drugs. VEGF-B may also be useful to increase the microvasculature of hypoxic areas of tumors and make them more sensitive to radiation, radiation sensitizing drugs, etc.

The angiogenic action of VEGF-B may be useful in treating ischemic conditions. Administration of an intra-arterial bolus of VEGF-B by the techniques described in Bauters et al., *American Journal of Physiology*, 267(4 Pt 2):H1263-71 (1994) may be useful to treat lower extremity ischemia and increase perfusion in the extremities. Using procedures described by Mesri et al., *Circulation Research*, 76:161-67 (1995) an angiogenic response may be produced in tissue injected with fibroblast cells transduced with a virus which expresses VEGF-B in order to treat tissue ischemia (e.g. myocardial ischemia). VEGF-B or agonists

could be used to stimulate the development of collateral circulation in cases of arterial and/or venous obstruction, e.g. myocardial infarcts, ischaemic limbs, deep venous thrombosis, and/or postpartum vascular problems; see  
5 Takeshita et al, *supra*.

A VEGF-B/VEGF-B receptor system may be used as an assay system to detect small molecules as agonists/antagonists for development as new drugs. Examples of small molecules which could be detected include, but are not limited to, organic  
10 chemicals, peptides, and RNA molecules.

Pharmaceutical compositions may be produced by admixing a pharmaceutically effective amount of VEGF-B protein with one or more suitable carriers or adjuvants such as water, mineral oil, polyethylene glycol, starch, talcum, lactose,  
15 thickeners, stabilizers, suspending agents, etc. Such compositions may be in the form of solutions, suspensions, tablets, capsules, creams, salves, ointments, or other conventional forms.

As demonstrated in Example 7, VEGF-B protein also can  
20 be used to produce antibodies. In general, conventional antibody production techniques may be used to produce VEGF-B antibodies. For example, specific monoclonal antibodies may be produced via immunization of fusion proteins obtained by recombinant DNA expression.

25 Labelled monoclonal antibodies, in particular, should be useful in screening for conditions associated with abnormal levels of VEGF-B in the body. For example, an assay of VEGF-B in synovial fluids and/or joint tissue by immunofluorometric techniques analogous to the the procedure  
30 described by Fava et al., *Journal of Experimental Medicine*, 180:341-46 (1994) may be useful as a diagnostic indicator of rheumatoid arthritis. A radioimmunoassay of VEGF-B in ocular fluid using techniques described by Aiello et al., in *New England Journal of Medicine*, 331(22):1480-87 (1994)  
35 may be useful as a diagnostic indicator of diabetic retinopathy, neovascularization of the iris or retinal vein

occlusion. Immunoassays of VEGF-B levels in blood, urine or other bodily fluids may be useful also as a tumor marker; see Kondo et al., *supra*. These monoclonal antibodies to VEGF-B also may be useful in inhibiting angiogenesis associated with high levels of VEGF-B in the body, e.g. in rapidly proliferating, angiogenesis-dependent tumors in mammals, and thereby may retard the growth of such tumors. Treatment with a monoclonal antibody specific for VEGF-B using techniques analogous to those described by Kim et al., in *Nature*, 362(6243):841-44 (1993) may be useful to suppress or inhibit tumor growth *in vivo*. Intravenous and/or subcutaneous injection of monoclonal antibodies to VEGF-B using procedures like those described by Asano et al., in *Cancer Research*, 55:5296-5301 (1995) may be useful to inhibit neovascularization and primary and metastatic growth of solid tumors. For the therapy of humans, chimerization or humanization of such monoclonal antibodies is to be preferred. Treatment may be effected, e.g., by twice weekly intraperitoneal injection of 10 to 500  $\mu$ g, preferably 50-100  $\mu$ g of monoclonal antibody.

VEGF-B antagonists such as antibodies also may be useful to inhibit new blood vessels in diabetic retinopathy, psoriasis, arthropathies and/or vascular tumors such as haemangiomas; see Aiello et al., *supra*.

The foregoing description and examples have been set forth merely to illustrate the invention and are not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

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OLOFSSON, Birgitta  
ALITALO, Kari  
PAJUSOLA, Katri
- (ii) TITLE OF INVENTION: VASCULAR ENDOTHELIAL GROWTH FACTOR-B AND  
DNA CODING THEREFOR
- (iii) NUMBER OF SEQUENCES: 31
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  - (E) COUNTRY: US
  - (F) ZIP: 20005
- (v) COMPUTER READABLE FORM:
  - (A) MEDIUM TYPE: Floppy disk
  - (B) COMPUTER: IBM PC compatible
  - (C) OPERATING SYSTEM: PC-DOS/MS-DOS
  - (D) SOFTWARE: PatentIn Release #1.0, Version #1.25
- (vi) CURRENT APPLICATION DATA:
  - (A) APPLICATION NUMBER: US
  - (B) FILING DATE: 01-MAR-1996
- (vii) PRIOR APPLICATION DATA:
  - (A) APPLICATION NUMBER: US 08/397,651
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- (vii) PRIOR APPLICATION DATA:
  - (A) APPLICATION NUMBER: US 08/469,427
  - (B) FILING DATE: 06-JUN-1995
- (vii) PRIOR APPLICATION DATA:
  - (A) APPLICATION NUMBER: US 08/569,063
  - (B) FILING DATE: 06-DEC-1995
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## (2) INFORMATION FOR SEQ ID NO:1:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 886 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO

(vi) ORIGINAL SOURCE:  
(F) TISSUE TYPE: mouse embryo

(vii) IMMEDIATE SOURCE:  
(B) CLONE: pcif2

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

```

CGGGACGCCC AGTGGTGCCA TGGATAGACG TTTATGCACG TGCCACATGC CAGCCCAGGG      60
AGGTGGTGGT GCCTCTGAGC ATGGAAGTCA TGGGCAATGT GGTCAAACAA CTAGTGCCCA      120
GCTGTGTGAC TGTGCAGCGC TGTGGTGGCT GCTGCCCTGA CGATGGCCTG GAATGTGTGC      180
CCACTGGGCA ACACCAAGTC CGAATGCAGA TCCTCATGAT CCAGTACCCG AGCAGTCAGC      240
TGGGGGAGAT GTCCCTGGAA GAACACAGCC AATGTGAATG CAGACCAAAA AAAAAAAGGA      300
GAGTGCTGTG AAGCCAGACA GCCCCAGGAT CCTCTGCCCC CCTTGACACC AGCGCCGTCA      360
ACGCCCTGAC CCCCAGACCT GCCGCTGCCG CTGCAGACGC CGCCGCTTCC TCCATTGCCA      420
AGGGCGGGGC TTAGAGCTCA ACCCAGACAC CTGTAGGTGC CGGAAGCCGC GAAAGTGACA      480
AGCTGCTTTC CAGACTCCAC GGGCCCGGCT GCTTTTATGG CCCTGCTTCA CAGGGACGAA      540
GAGTGGAGCA CAGGCAAACC TCCTCAGTCT GGGAGGTCAC TGCCCCAGGA CCTGGACCTT      600
TTAGAGAGCT CTCTCGCCAT CTTTATATCTC CCAGAGCTGC CATCTAACAA TTGTCAAGGA      660
ACCTCATGTC TCACCTCAGG GGCCAGGGTA CTCTCTCACT TAACCACCCT GGTCAAGTGA      720
GCATCTTCTG GCTGGCTGTC TCCCCTCACT ATGAAAACCC CAAACTTCTA CCAATAACGG      780
GATTGGGTT CTGTTATGAT AACTGTGACA CACACACACA CTCACACTCT GATAAAAGAG      840
AACTCTGATA AAAGAGATGG AAGACACTAA AAAAAAAAAA AAAAAA      886

```

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 102 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(iii) HYPOTHETICAL: NO

(vi) ORIGINAL SOURCE:  
(F) TISSUE TYPE: mouse embryo

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

```

Gly Arg Pro Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys
 1           5           10           15
Gln Pro Arg Glu Val Val Val Pro Leu Ser Met Glu Leu Met Gly Asn
          20           25           30
Val Val Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly
          35           40           45

```

Gly Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His  
 50 55 60  
 Gln Val Arg Met Gln Ile Leu Met Ile Gln Tyr Pro Ser Ser Gln Leu  
 65 70 75 80  
 Gly Glu Met Ser Leu Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys  
 85 90 95  
 Lys Lys Arg Arg Val Leu  
 100

## (2) INFORMATION FOR SEQ ID NO:3:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 55 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: protein
- (iii) HYPOTHETICAL: NO
- (vi) ORIGINAL SOURCE:
  - (F) TISSUE TYPE: mouse embryo
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

Lys Pro Asp Ser Pro Arg Ile Leu Cys Pro Pro Cys Thr Gln Arg Arg  
 1 5 10 15  
 Gln Arg Pro Asp Pro Arg Thr Cys Arg Cys Arg Cys Arg Arg Arg Arg  
 20 25 30  
 Phe Leu His Cys Gln Gly Arg Gly Leu Glu Leu Asn Pro Asp Thr Cys  
 35 40 45  
 Arg Cys Arg Lys Pro Arg Lys  
 50 55

## (2) INFORMATION FOR SEQ ID NO:4:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 565 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear
- (ii) MOLECULE TYPE: cDNA
- (iii) HYPOTHETICAL: NO
- (vi) ORIGINAL SOURCE:
  - (F) TISSUE TYPE: adult mouse heart
- (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

GAGCCCCCTG CTCCGTCGCC TGCTGCTTGT TGCACTGCTG CAGCTGGCTC GCACCCAGGC 60  
 CCCTGTGTCC CAGTTTGATG GCCCCAGCCA CCAGAAGAAA GTGGTGCCAT GGATAGACGT 120

```

TTATGCACGT GCCACATGCC AGCCCAGGGA GGTGGTGGTG CCTCTGAGCA TGGAAGTCAT      180
GGGCAATGTG GTCAAACAAC TAGTGCCCAG CTGTGTGACT GTGCAGCGCT GTGGTGGCTG      240
CTGCCCTGAC GATGGCCTGG AATGTGTGCC CACTGGGCAA CACCAAGTCC GAATGCAGAT      300
CCTCATGATC CAGTACCCGA GCAGTCAGCT GGGGGAGATG TCCCTGGAAG AACACAGCCA      360
ATGTGAATGC AGACCAAAAA AAAAGGAGAG TGCTGTGAAG CCAGACAGCC CCAGGATCCT      420
CTGCCCCGCT TGCACCCAGC GCCGTCAACG CCCTGACCCC CGGACCTGCC GCTGCCGCTG      480
CAGACGCCGC CGCTTCCTCC ATTGCCAAGG GCGGGGCTTA GAGCTCAACC CAGACACCTG      540
TAGGTGCCGG AAGCCGCGAA AGTGA                                           565

```

## (2) INFORMATION FOR SEQ ID NO:5:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 188 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(iii) HYPOTHETICAL: NO

## (vi) ORIGINAL SOURCE:

(F) TISSUE TYPE: adult mouse heart

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

```

Met Ser Pro Leu Leu Arg Arg Leu Leu Leu Val Ala Leu Leu Gln Leu
1           5           10           15
Ala Arg Thr Gln Ala Pro Val Ser Gln Phe Asp Gly Pro Ser His Gln
20          25          30
Lys Lys Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys Gln
35          40          45
Pro Arg Glu Val Val Val Pro Leu Ser Met Glu Leu Met Gly Asn Val
50          55          60
Val Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly Gly
65          70          75          80
Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His Gln
85          90          95
Val Arg Met Gln Ile Leu Met Ile Gln Tyr Pro Ser Ser Gln Leu Gly
100         105         110
Glu Met Ser Leu Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys Lys
115         120         125
Lys Glu Ser Ala Val Lys Pro Asp Ser Pro Arg Ile Leu Cys Pro Pro
130         135         140
Cys Thr Gln Arg Arg Gln Arg Pro Asp Pro Arg Thr Cys Arg Cys Arg
145         150         155         160

```

Cys Arg Arg Arg Arg Phe Leu His Cys Gln Gly Arg Gly Leu Glu Leu  
165 170 175

Asn Pro Asp Thr Cys Arg Cys Arg Lys Pro Arg Lys  
180 185

(2) INFORMATION FOR SEQ ID NO:6:

- ```
(i) SEQUENCE CHARACTERISTICS:
    (A) LENGTH: 591 base pairs
    (B) TYPE: nucleic acid
    (C) STRANDEDNESS: single
    (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(iv) ORIGINAL SOURCE:
    (F) TISSUE TYPE: adult mouse heart

(v) ORGANISM: Mus musculus

(vi) SEQUENCE DESCRIPTION: SEQ ID NO:6:
```

|             |            |            |            |            |            |     |
|-------------|------------|------------|------------|------------|------------|-----|
| ACCATGAGCC  | CCCTGCTCCG | TCGCCTGCTG | CTTGTTGCAC | TGCTGCAGCT | GGCTCGCACC | 60  |
| CAGGCCCCCTG | TGTCCCAGTT | TGATGGCCCC | AGCCACCAGA | AGAAAGTGGT | GCCATGGATA | 120 |
| GACGTTTATG  | CACGTGCCAC | ATGCCAGCCC | AGGGAGGTGG | TGGTGCCTCT | GAGCATGGAA | 180 |
| CTCATGGGCA  | ATGTGGTCAA | ACAACTAGTG | CCCAGCTGTG | TGACTGTGCA | GCGCTGTGGT | 240 |
| GGCTGCTGCC  | CTGACGATGG | CCTGGAATGT | GTGCCCCTG  | GGCAACACCA | AGTCCGAATG | 300 |
| CAGGTACCAG  | GGCCTATGGG | TCAGATCCTC | ATGATCCAGT | ACCCGAGCAG | TCAGCTGGGG | 360 |
| GAGATGTCCC  | TGGAAGAAC  | CAGCCAATGT | GAATGCAGAC | CAAAAAAAAA | GGAGAGTGCT | 420 |
| GTGAAGCCAG  | ACAGCCCCAG | GATCCTCTGC | CCGCCTTGCA | CCCAGCGCCG | TCAACGCCCT | 480 |
| GACCCCCGGA  | CCTGCCGCTG | CCGCTGCAGA | CGCCGCCGCT | TCCTCCATTG | CCAAGGGCGG | 540 |
| GGCTTAGAGC  | TCAACCCAGA | CACCTGTAGG | TGCCGGAAGC | CGCGAAAGTG | A          | 591 |

## (2) INFORMATION FOR SEQ ID NO:7:

- ```
(i) SEQUENCE CHARACTERISTICS:
      (A) LENGTH: 195 amino acids
      (B) TYPE: amino acid
      (C) STRANDEDNESS: single
      (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(iii) HYPOTHETICAL: NO

(vi) ORIGINAL SOURCE:
      (F) TISSUE TYPE: adult mouse heart

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:
```

Met Ser Pro Leu Leu Arg Arg Leu Leu Leu Val Ala Leu Leu Gln Leu  
1 5 10 15

Ala Arg Thr Gln Ala Pro Val Ser Gln Phe Asp Gly Pro Ser His Gln  
 20 25 30  
 Lys Lys Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys Gln  
 35 40 45  
 Pro Arg Glu Val Val Val Pro Leu Ser Met Glu Leu Met Gly Asn Val  
 50 55 60  
 Val Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly Gly  
 65 70 75 80  
 Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His Gln  
 85 90 95  
 Val Arg Met Gln Val Pro Gly Pro Met Gly Gln Ile Leu Met Ile Gln  
 100 105 110  
 Tyr Pro Ser Ser Gln Leu Gly Glu Met Ser Leu Glu Glu His Ser Gln  
 115 120 125  
 Cys Glu Cys Arg Pro Lys Lys Lys Glu Ser Ala Val Lys Pro Asp Ser  
 130 135 140  
 Pro Arg Ile Leu Cys Pro Pro Cys Thr Gln Arg Arg Gln Arg Pro Asp  
 145 150 155 160  
 Pro Arg Thr Cys Arg Cys Arg Cys Arg Arg Arg Arg Phe Leu His Cys  
 165 170 175  
 Gln Gly Arg Gly Leu Glu Leu Asn Pro Asp Thr Cys Arg Cys Arg Lys  
 180 185 190  
 Pro Arg Lys  
 195

## (2) INFORMATION FOR SEQ ID NO:8:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 405 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

ACCATGAGCC CCCTGCTCCG TCGCCTGCTG CTTGTTGCAC TGCTGCAGCT GGCTCGCACC	60
CAGGCCCTTG TGTCCAGTT TGATGGCCCC AGCCACCAGA AGAAAGTGGT GCCATGGATA	120
GACGTTTATG CACGTGCCAC ATGCCAGCCC AGGGAGGTGG TGGTGCCTCT GAGCATGGAA	180
CTCATGGGCA ATGTGGTCAA ACAACTAGTG CCCAGCTGTG TGA CTGTGCA GCGCTGTGGT	240
GGCTGTGCC CTGACGATGG CCTGGAATGT GTGCCCCACTG GGCAACACCA AGTCCGAATG	300
CAGATCCTCA TGATCCAGTA CCCGAGCAGT CAGCTGGGGG AGATGTCCCT GGAAGAACAC	360
AGCCAATGTG AATGCAGACC AAAAAAAAAA AGGAGAGTGC TGTGA	405

## (2) INFORMATION FOR SEQ ID NO:9:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 133 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

```

Met Ser Pro Leu Leu Arg Arg Leu Leu Leu Val Ala Leu Leu Gln Leu
 1           5           10           15
Ala Arg Thr Gln Ala Pro Val Ser Gln Phe Asp Gly Pro Ser His Gln
 20           25           30
Lys Lys Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys Gln
 35           40           45
Pro Arg Glu Val Val Val Pro Leu Ser Met Glu Leu Met Gly Asn Val
 50           55           60
Val Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly Gly
 65           70           75           80
Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His Gln
 85           90           95
Val Arg Met Gln Ile Leu Met Ile Gln Tyr Pro Ser Ser Gln Leu Gly
100           105           110
Glu Met Ser Leu Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys Lys
115           120           125
Lys Arg Arg Val Leu
130

```

## (2) INFORMATION FOR SEQ ID NO:10:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 570 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(vi) ORIGINAL SOURCE:  
 (F) TISSUE TYPE: human fibrosarcoma

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

```

ACCATGAGCC CTCTGCTCCG CCGCCTGCTG CTCGCCGCAC TCCTGCAGCT GGCCCCCGCC      60
CAGGCCCCCTG TCTCCCAGCC TGATGCCCCT GGCCACCAGA GGAAAGTGGT GTCATGGATA      120
GATGTGTATA CTCGCGCTAC CTGCCAGCCC CGGGAGGTGG TGGTGCCCTT GACTGTGGAG      180
CTCATGGGCA CCGTGGCCAA ACAGCTGGTG CCCAGCTGCG TGACTGTGCA GCGCTGTGGT      240

```

```

GGCTGCTGCC CTGACGATGG CCTGGAGTGT GTGCCCCTG GGCAGCACCA AGTCCGGATG      300
CAGATCCTCA TGATCCGGTA CCCGAGCAGT CAGCTGGGGG AGATGTCCCT GGAAGAACAC      360
AGCCAGTGTG AATGCAGACC TAAAAAAG GACAGTGTG TGAAGCCAGA CAGCCCCAGG      420
CCCCCTGCTG CACGCTGCAC CCAGCACCAC CAGCGCCCTG ACCCCCGGAC CTGCCGCTGC      480
CGCTGCCGAC GCCGCAGCTT CCTCCGTTGC CAAGGGCGGG GCTTAGAGCT CAACCCAGAC      540
ACCTGCAGGT GCCGGAAGCT GCGAAGGTGA      570

```

## (2) INFORMATION FOR SEQ ID NO:11:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 188 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: protein

## (iii) HYPOTHETICAL: NO

## (vi) ORIGINAL SOURCE:

- (F) TISSUE TYPE: human fibrosarcoma

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

```

Met Ser Pro Leu Leu Arg Arg Leu Leu Leu Ala Ala Leu Leu Gln Leu
1           5           10           15
Ala Pro Ala Gln Ala Pro Val Ser Gln Pro Asp Ala Pro Gly His Gln
20           25           30
Arg Lys Val Val Ser Trp Ile Asp Val Tyr Thr Arg Ala Thr Cys Gln
35           40           45
Pro Arg Glu Val Val Val Pro Leu Thr Val Glu Leu Met Gly Thr Val
50           55           60
Ala Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly Gly
65           70           75           80
Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His Gln
85           90           95
Val Arg Met Gln Ile Leu Met Ile Arg Tyr Pro Ser Ser Gln Leu Gly
100          105          110
Glu Met Ser Leu Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys Lys
115          120          125
Lys Asp Ser Ala Val Lys Pro Asp Ser Pro Arg Pro Leu Cys Pro Arg
130          135          140
Cys Thr Gln His His Gln Arg Pro Asp Pro Arg Thr Cys Arg Cys Arg
145          150          155          160
Cys Arg Arg Arg Ser Phe Leu Arg Cys Gln Gly Arg Gly Leu Glu Leu
165          170          175
Asn Pro Asp Thr Cys Arg Cys Arg Lys Leu Arg Arg
180          185

```

## (2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 624 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(iii) HYPOTHETICAL: NO

(vi) ORIGINAL SOURCE:  
 (F) TISSUE TYPE: mouse

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

```

ATGAGCCCCC TGCTCCGTCG CCTGCTGCTT GTTGCACTGC TGCAGCTGGC TCGCACCCAG      60
GCCCTGTGT CCCAGTTTGA TGGCCCCAGC CACCAGAAGA AAGTGGTGCC ATGGATAGAC      120
GTTTATGCAC GTGCCACATG CCAGCCCAGG GAGGTGGTGG TGCCTCTGAG CATGGAACCTC      180
ATGGGCAATG TGGTCAAACA ACTAGTGCCC AGCTGTGTGA CTGTGCAGCG CTGTGGTGGC      240
TGCTGCCCTG ACGATGGCCT GGAATGTGTG CCCACTGGGC AACACCAAGT CCGAATGCAG      300
ATCCTCATGA TCCAGTACCC GAGCAGTCAG CTGGGGGAGA TGTCCCTGGA AGAACACAGC      360
CAATGTGAAT GCAGACCAAA AAAAAAGGAG AGTGCTGTGA AGCCAGACAG GGTTGCCATA      420
CCCCACCACC GTCCCCAGCC CCGCTCTGTT CCGGGCTGGG ACTCTACCCC GGGAGCATCC      480
TCCCCAGCTG ACATCATCCA TCCCACTCCA GCCCCAGGAT CCTCTGCCCC CTTGCACCC      540
AGCGCCGTCA ACGCCCTGAC CCCCAGGACCT GCCGCTGCCG CTGCAGACGC CGCCGCTTCC      600
TCCATTGCCA AGGGCGGGGC TTAG                                     624
  
```

## (2) INFORMATION FOR SEQ ID NO:13:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 207 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(vi) ORIGINAL SOURCE:  
 (F) TISSUE TYPE: mouse

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

```

Met Ser Pro Leu Leu Arg Arg Leu Leu Val Ala Leu Leu Gln Leu
 1           5           10           15
Ala Arg Thr Gln Ala Pro Val Ala Gln Phe Asp Gly Pro Ser His Gln
          20           25           30
Lys Lys Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys Gln
          35           40           45
  
```

Pro Arg Glu Val Val Val Pro Leu Ser Met Glu Leu Met Gly Asn Val  
 50 55 60  
 Val Lys Gln Leu Val Pro Ser Cys Val Thr Val Gln Arg Cys Gly Gly  
 65 70 75 80  
 Cys Cys Pro Asp Asp Gly Leu Glu Cys Val Pro Thr Gly Gln His Gln  
 85 90 95  
 Val Arg Met Gln Ile Leu Met Ile Gln Tyr Pro Ser Ser Gln Leu Gly  
 100 105 110  
 Glu Met Ser Leu Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys Lys  
 115 120 125  
 Lys Glu Ser Ala Val Lys Pro Asp Arg Val Ala Ile Pro His His Arg  
 130 135 140  
 Pro Gln Pro Arg Ser Val Pro Gly Trp Asp Ser Thr Pro Gly Ala Ser  
 145 150 155 160  
 Ser Pro Ala Asp Ile Ile His Pro Thr Pro Ala Pro Gly Ser Ser Ala  
 165 170 175  
 Arg Leu Ala Pro Ser Ala Val Asn Ala Leu Thr Pro Gly Pro Ala Ala  
 180 185 190  
 Ala Ala Ala Asp Ala Ala Ala Ser Ser Ile Ala Lys Gly Gly Ala  
 195 200 205

## (2) INFORMATION FOR SEQ ID NO:14:

- (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 624 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(vi) ORIGINAL SOURCE:

- (F) TISSUE TYPE: human

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

ATGAGCCCTC TGCTCCGCCG CCTGCTGCTC GCCGCACTCC TGCAGCTGGC CCCC GCCCAG	60
GCCCCTGTCT CCCAGCCTGA TGCCCTGGC CACCAGAGGA AAGTGGTGTC ATGGATAGAT	120
GTGTATACTC GCGCTACCTG CCAGCCCCGG GAGGTGGTGG TGCCCTTGAC TGTGGAGCTC	180
ATGGGCACCG TGGCCAAACA GCTGGTGCCC AGCTGCGTGA CTGTGCAGCG CTGTGGTGGC	240
TGCTGCCCTG ACGATGGCCT GGAGTGTGTG CCCACTGGGC AGCACCAAGT CCGGATGCAG	300
ATCCTCATGA TCCGGTACCC GAGCAGTCAG CTGGGGGAGA TGTCCCTGGA AGAACACAGC	360
CAGTGTGAAT GCAGACCTAA AAAAAAGGAC AGTGCTGTGA AGCCAGACAG GGCTGCCACT	420
CCCCACCACC GTCCCCAGCC CCGTTCTGTT CCGGGCTGGG ACTCTGCCCC CGGAGCACCC	480
TCCCCAGCTG ACATCACCCA TCCCCTCCA GCCCCAGGCC CCTCTGCCCA CGCTGCACCC	540

AGCACCACCA GCGCCCTGAC CCCCGGACCT GCCGCCGCCG CTGCCGACGC CGCAGCTTCC 600  
 TCCGTTGCCA AGGGCGGGGC TTAG 624

## (2) INFORMATION FOR SEQ ID NO:15:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 207 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(vi) ORIGINAL SOURCE:  
 (F) TISSUE TYPE: human

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

Met	Ser	Pro	Leu	Leu	Arg	Arg	Leu	Leu	Leu	Ala	Ala	Leu	Leu	Gln	Leu	1	5	10	15
Ala	Pro	Ala	Gln	Ala	Pro	Val	Ser	Gln	Pro	Asp	Ala	Pro	Gly	His	Gln	20	25	30	
Arg	Lys	Val	Val	Ser	Trp	Ile	Asp	Val	Tyr	Thr	Arg	Ala	Thr	Cys	Gln	35	40	45	
Pro	Arg	Glu	Val	Val	Val	Pro	Leu	Thr	Val	Glu	Leu	Met	Gly	Thr	Val	50	55	60	
Ala	Lys	Gln	Leu	Val	Pro	Ser	Cys	Val	Thr	Val	Gln	Arg	Cys	Gly	Gly	65	70	75	80
Cys	Cys	Pro	Asp	Asp	Gly	Leu	Glu	Cys	Val	Pro	Thr	Gly	Gln	His	Gln	85	90	95	
Val	Arg	Met	Gln	Ile	Leu	Met	Ile	Arg	Tyr	Pro	Ser	Ser	Gln	Leu	Gly	100	105	110	
Glu	Met	Ser	Leu	Glu	Glu	His	Ser	Gln	Cys	Glu	Cys	Arg	Pro	Lys	Lys	115	120	125	
Lys	Asp	Ser	Ala	Val	Lys	Pro	Asp	Arg	Ala	Ala	Thr	Pro	His	His	Arg	130	135	140	
Pro	Gln	Pro	Arg	Ser	Val	Pro	Gly	Trp	Asp	Ser	Ala	Pro	Gly	Ala	Pro	145	150	155	160
Ser	Pro	Ala	Asp	Ile	Thr	His	Pro	Thr	Pro	Ala	Pro	Gly	Pro	Ser	Ala	165	170	175	
His	Ala	Ala	Pro	Ser	Thr	Thr	Ser	Ala	Leu	Thr	Pro	Gly	Pro	Ala	Ala	180	185	190	
Ala	Ala	Ala	Asp	Ala	Ala	Ala	Ser	Ser	Val	Ala	Lys	Gly	Gly	Ala	195	200	205		

## (2) INFORMATION FOR SEQ ID NO:16:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 13 amino acids

(B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

Pro Xaa Cys Val Xaa Xaa Xaa Arg Cys Xaa Gly Cys Cys  
 1 5 10

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 1550 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

```
CTCGAGATCT GTTTGTGTC TTGGAACAAT ACGGTTTAGA GGTGACTGGC GGGTGACGAG      60
AACATATGCG AGTTCACCTA AGAGAAAAGC TGAATGAGGC AATGCCTCTT CCTGACCATA      120
TCTCTTACTC AGATAACTAT AGAATTTATT GTCCAGTAA GGGTATATTA AAAAATCATA      180
TTAAAAGTCA TACAGTGAAG TTGTCCAGGG AAATCAAGAC TTAACAGTCT CACTCTGACA      240
ATAATGAACA GGGGGATTCC CTCAAGATAG ACTAGGACAT GACCCACAC TGGCAGGTAG      300
TAGTACCAGA AAAGAACGCA TGGAAAATCT TTACCTTATG CTTGAGGTAG GGACCAGGCT      360
AAAGTGAAGG CCAGACCTAA AATTCTATCT AAAATAAATC CACAATCGAA GAAAATATGT      420
GGTGTACAGG TATAGAATGT CTTTACTGGA TCATTGAAAT AGTAAGATAA ATTCAACTTT      480
TTACATTGTT TTCTTTTCCT CCAGTTAGGG CTTGAGACCT TCGTCTCTGG AGAGTGACTG      540
TCAATTGGAG CCCTGCTTTC TGGGTTTCTG GCCAGGGGGG TTGTGGATGC TTAACATGTG      600
CCTTTCACAG GACACTTCCT TACCCAGCA GTGGCCANGT GTGCATCCCA CGACCAGGCC      660
TCCCTCTCAC GGAACATCTG TTGAGACTAG GAGATGCCTG GTGACTGTTG CCTGACCTGT      720
GTCCTGTGTA TTTCTGACAA GAGCCACTCT CAAAGACCCT GGCCAGGAGG AGAGTTAGGT      780
TCCAGTGTAG GTCAGCTCAG ACAGATGGAG GCCACAGAAN CAAACATGGG AAATCACAGA      840
AGTAGGTTTA TTACTCACAG ATCCCTATCC CAACCACCCA GGTGCCCTCT CCTCCAGGGC      900
CAACAGAGGC ATCCTTCAGC AGGAGCGACA ACGGCTAGGG CAGCGGCAAG CCGCCACCAT      960
CCGAGCCAAC CCAGGCCCGG AGATCGTGCC CCGGGGCGCC GGCCCCTGAG GGGCTCACCT      1020
GGATGGGGCC TGCATGCGTT CCCGCTTTGC TTCCTTCCCT GGACGGCCCG CTCCCCGAA      1080
ACGCGCCGCC AATAAAGTGA TTCGCAGAGC TCGTGTGCGG CTCCCTCCTT AAGGCCCCGAC      1140
GCCCCGCGCC CCGGCCTCGC CAAGGGCAGC GCCCCGGCCT CCGGGTAGTG GCGGCCGGCG      1200
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ACTGGGGAGC CCAGCCTCCT GGGCGGTGCG TCCCCTTCCC CCTGCCGCGG CGGGAGGCGG 1260  
 GAGGGGGTGT GTGGAGGAGG CGGGCCCCCG CGACGGCCTC GGGCCCCCAC CCCGCCGCCC 1320  
 CGCCCCCGCC CCACGGGCCC GGTGGGGAGC GCGTGTCTGG GTCACATGAG CCGCCTGCCC 1380  
 GCCAGCCCGG GCCCAGCCCC CCGCCGCCCC CGCCGTCCCC GCGCCGCTG CCCGCCGCCA 1440  
 CCGGCCGCCC GCCCGCCCGG CTCCTCCGGC CGCCTTCGCT GCGCTGCNTG CGCTGCCTGC 1500  
 ACCCAGGGCT CGGGAGGGGG CCGCGGAGGA GCCGCCCCC GCGCCCGGCC 1550

## (2) INFORMATION FOR SEQ ID NO:18:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 20 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

CACCATGAGC CCTCTGCTCC

20

## (2) INFORMATION FOR SEQ ID NO:19:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 20 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

GCCATGTGTC ACCTTCGCAG

20

## (2) INFORMATION FOR SEQ ID NO:20:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 21 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

GGGCATCAGG CTGGGAGACA G

21

## (2) INFORMATION FOR SEQ ID NO:21:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 18 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Cys Pro Val Ser Gln Phe Asp Gly Pro Ser His Gln Lys Lys Val Val  
1 5 10 15

Pro Cys

(2) INFORMATION FOR SEQ ID NO:22:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 23 amino acids
- (B) TYPE: amino acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

Ser Gln Pro Asp Ala Pro Gly His Gln Arg Lys Val Val Ser Trp Ile  
1 5 10 15

Asp Val Tyr Thr Arg Ala Thr  
20

(2) INFORMATION FOR SEQ ID NO:23:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 19 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

CACAGCCAAT GTGAATGCA

19

(2) INFORMATION FOR SEQ ID NO:24:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 31 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:

GCTCTAAGCC CCGCCCTTGG CAATGGAGGA A

31

(2) INFORMATION FOR SEQ ID NO:25:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 28 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:

ACGTAGATCT TCACTTTCGC GGCTTCCG

28

(2) INFORMATION FOR SEQ ID NO:26:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 23 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:

CTCTGTTCCG GGCTGGGACT CTA

23

(2) INFORMATION FOR SEQ ID NO:27:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 27 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:

TCAGGGCGTT GACGGCGCTG GGTGCAA

27

(2) INFORMATION FOR SEQ ID NO:28:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 21 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:

CCTGACGATG GCCTGGAGTG T

21

(2) INFORMATION FOR SEQ ID NO:29:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 21 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:

TGTCCCTGGA AGAACACAGC C

21

(2) INFORMATION FOR SEQ ID NO:30:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 20 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:

CGGGAAATCG TCGTGACAT

20

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 21 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: single
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

GGAGTTGAAG GTAGTTTCGT G

21

What is claimed is:

1. An isolated DNA which codes for a protein which comprises a characteristic amino acid sequence

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys (SEQ ID NO:16) and has the property of promoting proliferation of endothelial cells or mesodermal cells, said DNA being selected from the group consisting of the DNA of Figures 1 and 2 (SEQ ID NO:1), the DNA of Figure 3 (SEQ ID NO:4), the DNA of Figure 5 (SEQ ID NO:6), the DNA of Figure 7 (SEQ ID NO:8), the DNA of Figure 10 (SEQ ID NO:10), the DNA of Figure 12 (SEQ ID NO:12), the DNA of Figure 14 (SEQ ID NO:14), and DNA which hybridizes under stringent conditions with at least one of the foregoing DNA sequences.

2. A DNA according to claim 1, wherein said DNA is a cDNA.

3. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figures 1 and 2 (SEQ ID NO:1).

4. A DNA according to claim 1, wherein said DNA sequence is a mammalian DNA.

5. A DNA according to claim 4, wherein said DNA is a murine DNA.

6. A DNA according to claim 4, wherein said DNA is a human DNA.

7. A DNA according to claim 1, wherein said DNA codes for a protein which promotes proliferation of vascular endothelial cells.

8. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 3 (SEQ ID NO:4).

9. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 5 (SEQ ID NO:6).

10. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 7 (SEQ ID NO:8).

11. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 10 (SEQ ID NO:10).

12. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 12 (SEQ ID NO:12).

13. A DNA according to claim 1, comprising a cDNA corresponding to the DNA of Figure 14 (SEQ ID NO:14).

14. A vector comprising a DNA according to claim 1.

15. A vector according to claim 14, wherein said vector is a eukaryotic vector.

16. A vector according to claim 14, wherein said vector is a prokaryotic vector.

17. A vector according to claim 14, wherein said vector is a plasmid.

18. A protein which exhibits a characteristic sequence Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys (SEQ ID NO:16) and has the property of promoting proliferation of endothelial cells or mesodermal cells, said protein comprising a sequence of amino acids substantially corresponding to an amino acid sequence selected from the group consisting of the amino acid sequence of Figure 1 (SEQ ID NO:2), the amino acid sequence of Figure 2 (SEQ ID NO:3), the amino acid sequence of Figure 4 (SEQ ID NO:5), the amino acid sequence of Figure 6 (SEQ ID NO:7), the amino acid

sequence of Figure 8 (SEQ ID NO:9), the amino acid sequence of Figure 11 (SEQ ID NO:11), the amino acid sequence of Figure 13 (SEQ ID NO:13), and the amino acid sequence of Figure 15 (SEQ ID NO:15).

19. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 1 (SEQ ID NO:2).

20. A protein according to claim 18, wherein said protein comprises an amino acid sequence corresponding to the amino acid sequence of Figure 2 (SEQ ID NO:3).

21. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 4 (SEQ ID NO:5).

22. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 6 (SEQ ID NO:7).

23. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 8 (SEQ ID NO:9).

24. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 11 (SEQ ID NO:11).

25. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 13 (SEQ ID NO:13).

26. A protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 15 (SEQ ID NO:15).

27. A protein according to claim 18, wherein said protein is a mammalian protein.

28. A protein according to claim 27, wherein said protein is a murine protein.

29. A protein according to claim 27, wherein said protein is a human protein.

30. A protein according to claim 18, wherein said protein promotes proliferation of vascular endothelial cells.

31. A protein produced by expression of a DNA selected from the group consisting of the DNA of Figures 1 and 2 (SEQ ID NO:1), the DNA of Figure 3 (SEQ ID NO:4), the DNA of Figure 5 (SEQ ID NO:6), the DNA of Figure 7 (SEQ ID NO:8), the DNA of Figure 10 (SEQ ID NO:10), the DNA of Figure 12 (SEQ ID NO:12), the DNA of Figure 14 (SEQ ID NO:14), and DNA which hybridizes under stringent conditions with at least one of the foregoing DNA sequences.

32. A pharmaceutical composition comprising an effective endothelial or mesodermal cell proliferation promoting amount of a protein according to claim 18, and at least one conventional pharmaceutical carrier or diluent.

33. An antibody which reacts with a protein according to claim 18.

34. An antibody according to claim 33, wherein said antibody is a monoclonal antibody.

35. A host cell transformed or transfected with a vector according to claim 14, such that said host cell expresses a protein having the property of promoting proliferation of endothelial or mesodermal cells.

36. A transfected host cell according to claim 35, wherein said host cell is a eukaryotic cell.

37. A transfected host cell according to claim 35, wherein said host cell is a COS cell.

38. A transformed host cell according to claim 35, wherein said host cell is a prokaryotic cell.

39. A transformed host cell according to claim 35, wherein said host cell is a 293EBNA cell.

40. A transformed host cell according to claim 35, wherein said host cell is an insect cell.

41. A diagnostic means for quantitatively detecting VEGF-B in a test sample, said means comprising an antibody according to claim 33, which reacts with VEGF-B in order to detect the amount of VEGF-B in the sample.

42. A diagnostic means according to claim 41, wherein said antibody is a labelled antibody.

43. A diagnostic means for detecting VEGF-B in a test sample, said means comprising at least one pair of primers complementary to a DNA sequence according to claim 1, for amplifying a test VEGF-B gene by polymerase chain reaction in order to facilitate a sequence comparison of the test VEGF-B gene with the DNA sequence according to claim 1.

44. A pharmaceutical composition comprising an effective VEGF-B-binding amount of antibodies according to claim 33.

45. A pharmaceutical composition comprising an effective endothelial or mesodermal cell proliferation promoting amount of a protein according to claim 18, and VEGF.

46. A pharmaceutical composition according to claim 45, further comprising an amount of heparin effective to assure that a cell proliferation promoting amount of said protein is present free from association with a cell.

47. A pharmaceutical composition according to claim 32, further comprising an amount of heparin effective to assure that a cell proliferation promoting amount of said protein is present free from association with a cell.

48. A pharmaceutical composition comprising an effective angiogenesis stimulating amount of a protein according to claim 18, and heparin.

49. A protein dimer comprising a protein according to claim 18.

50. A protein dimer according to claim 49, wherein said protein dimer is a homodimer of said protein.

51. A protein dimer according to claim 49, wherein said protein dimer is a heterodimer of said protein and VEGF.

52. A protein dimer according to claim 49, wherein said protein dimer is a disulfide-linked dimer.

53. A method of promoting release of at least one protein selected from the group consisting of proteins according to claim 18, and VEGF from a cell which expresses said at least one protein, said method comprising exposing the cell to heparin.

54. A vector comprising an anti-sense nucleotide sequence complementary to at least part of a DNA sequence according to claim 1.

55. A method of retarding expression of VEGF-B from a cell which expresses VEGF-B, said method comprising transfecting said cell with a vector according to claim 54.

56. A method according to claim 55, wherein said cell is a tumor cell.

57. An isolated DNA comprising a nucleotide sequence corresponding to the sequence of Figure 25 (SEQ ID NO:17) or a DNA which hybridizes under stringent conditions to said nucleotide sequence.

## AMENDED CLAIMS

[received by the International Bureau on 14 August 1996 (14.08.96);  
original claims 1-14, 18-31, 43, 44, 49-52 and 57 amended;  
new claims 58-63 added; remaining claims unchanged (8 pages)]

1. An isolated nucleic acid which codes for a protein which comprises a characteristic amino acid sequence

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys (SEQ ID NO:16) and has the property of promoting proliferation of endothelial cells or mesodermal cells, said nucleic acid being selected from the group consisting of the DNA of Figures 1 and 2 (SEQ ID NO:1), the DNA of Figure 3 (SEQ ID NO:4), the DNA of Figure 5 (SEQ ID NO:6), the DNA of Figure 7 (SEQ ID NO:8), the DNA of Figure 10 (SEQ ID NO:10), the DNA of Figure 12 (SEQ ID NO:12), the DNA of Figure 14 (SEQ ID NO:14), and nucleic acid which hybridizes under stringent conditions with at least one of the foregoing DNA sequences.

2. A nucleic acid according to claim 1, wherein said nucleic acid is a cDNA.

3. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figures 1 and 2 (SEQ ID NO:1).

4. A nucleic acid according to claim 1, wherein said nucleic acid sequence is a mammalian DNA.

5. A nucleic acid according to claim 4, wherein said nucleic acid is a murine DNA.

6. A nucleic acid according to claim 4, wherein said nucleic acid is a human DNA.

7. A nucleic acid according to claim 1, wherein said nucleic acid codes for a protein which promotes proliferation of vascular endothelial cells.

8. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 3 (SEQ ID NO:4).

9. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 5 (SEQ ID NO:6).

10. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 7 (SEQ ID NO:8).

11. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 10 (SEQ ID NO:10).

12. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 12 (SEQ ID NO:12).

13. A nucleic acid according to claim 1, comprising a cDNA corresponding to the DNA of Figure 14 (SEQ ID NO:14).

14. A vector comprising a nucleic acid according to claim 1, operably linked with a promoter sequence.

15. A vector according to claim 14, wherein said vector is a eukaryotic vector.

16. A vector according to claim 14, wherein said vector is a prokaryotic vector.

17. A vector according to claim 14, wherein said vector is a plasmid.

18. An isolated protein which exhibits a characteristic sequence

Pro-Xaa-Cys-Val-Xaa-Xaa-Xaa-Arg-Cys-Xaa-Gly-Cys-Cys (SEQ ID NO:16) and has the property of promoting proliferation of endothelial cells or mesodermal cells, said protein comprising a sequence of amino acids substantially corresponding to an amino acid sequence selected from the group consisting of the amino acid sequence of Figure 1 (SEQ ID NO:2), the amino acid sequence of Figure 2 (SEQ ID NO:3), the amino acid sequence of Figure 4 (SEQ ID NO:5), the amino acid sequence of Figure 6 (SEQ ID NO:7), the amino acid

sequence of Figure 8 (SEQ ID NO:9), the amino acid sequence of Figure 11 (SEQ ID NO:11), the amino acid sequence of Figure 13 (SEQ ID NO:13), and the amino acid sequence of Figure 15 (SEQ ID NO:15).

19. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 1 (SEQ ID NO:2).

20. An isolated protein according to claim 18, wherein said protein comprises an amino acid sequence corresponding to the amino acid sequence of Figure 2 (SEQ ID NO:3).

21. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 4 (SEQ ID NO:5).

22. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 6 (SEQ ID NO:7).

23. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 8 (SEQ ID NO:9).

24. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 11 (SEQ ID NO:11).

25. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 13 (SEQ ID NO:13).

26. An isolated protein according to claim 18, wherein said protein comprises a sequence of amino acids corresponding to the amino acid sequence of Figure 15 (SEQ ID NO:15).

27. An isolated protein according to claim 18, wherein said protein is a mammalian protein.

28. An isolated protein according to claim 27, wherein said protein is a murine protein.

29. An isolated protein according to claim 27, wherein said protein is a human protein.

30. An isolated protein according to claim 18, wherein said protein promotes proliferation of vascular endothelial cells.

31. An isolated protein produced by expression of a DNA selected from the group consisting of the DNA of Figures 1 and 2 (SEQ ID NO:1), the DNA of Figure 3 (SEQ ID NO:4), the DNA of Figure 5 (SEQ ID NO:6), the DNA of Figure 7 (SEQ ID NO:8), the DNA of Figure 10 (SEQ ID NO:10), the DNA of Figure 12 (SEQ ID NO:12), the DNA of Figure 14 (SEQ ID NO:14), and DNA which hybridizes under stringent conditions with at least one of the foregoing DNA sequences.

32. A pharmaceutical composition comprising an effective endothelial or mesodermal cell proliferation promoting amount of a protein according to claim 18, and at least one conventional pharmaceutical carrier or diluent.

33. An antibody which reacts with a protein according to claim 18.

34. An antibody according to claim 33, wherein said antibody is a monoclonal antibody.

35. A host cell transformed or transfected with a vector according to claim 14, such that said host cell expresses a protein having the property of promoting proliferation of endothelial or mesodermal cells.

36. A transfected host cell according to claim 35, wherein said host cell is a eukaryotic cell.

37. A transfected host cell according to claim 35, wherein said host cell is a COS cell.

38. A transformed host cell according to claim 35, wherein said host cell is a prokaryotic cell.

39. A transformed host cell according to claim 35, wherein said host cell is a 293EBNA cell.

40. A transformed host cell according to claim 35, wherein said host cell is an insect cell.

41. A diagnostic means for quantitatively detecting VEGF-B in a test sample, said means comprising an antibody according to claim 33, which reacts with VEGF-B in order to detect the amount of VEGF-B in the sample.

42. A diagnostic means according to claim 41, wherein said antibody is a labelled antibody.

43. A diagnostic means for detecting VEGF-B in a test sample, said means comprising at least one pair of primers complementary to a nucleic acid sequence according to claim 1, for amplifying a test VEGF-B gene by polymerase chain reaction in order to facilitate a sequence comparison of the test VEGF-B gene with the nucleic acid sequence according to claim 1.

44. A pharmaceutical composition comprising an effective VEGF-B-binding amount of antibodies according to claim 33, and at least one pharmaceutically acceptable carrier or adjuvant.

45. A pharmaceutical composition comprising an effective endothelial or mesodermal cell proliferation promoting amount of a protein according to claim 18, and VEGF.

46. A pharmaceutical composition according to claim 45, further comprising an amount of heparin effective to assure that a cell proliferation promoting amount of said protein is present free from association with a cell.

47. A pharmaceutical composition according to claim 32, further comprising an amount of heparin effective to assure that a cell proliferation promoting amount of said protein is present free from association with a cell.

48. A pharmaceutical composition comprising an effective angiogenesis stimulating amount of a protein according to claim 18, and heparin.

49. An isolated protein dimer comprising a protein according to claim 18.

50. An isolated protein dimer according to claim 49, wherein said protein dimer is a homodimer of said protein.

51. An isolated protein dimer according to claim 49, wherein said protein dimer is a heterodimer of said protein and VEGF.

52. An isolated protein dimer according to claim 49, wherein said protein dimer is a disulfide-linked dimer.

53. A method of promoting release of at least one protein selected from the group consisting of proteins according to claim 18, and VEGF from a cell which expresses said at least one protein, said method comprising exposing the cell to heparin.

54. A vector comprising an anti-sense nucleotide sequence complementary to at least part of a nucleic acid sequence according to claim 1.

55. A method of retarding expression of VEGF-B from a cell which expresses VEGF-B, said method comprising transfecting said cell with a vector according to claim 54.

56. A method according to claim 55, wherein said cell is a tumor cell.

57. An isolated nucleic acid comprising a nucleotide sequence corresponding to the sequence of Figure 25 (SEQ ID NO:17) or a nucleic acid which hybridizes under stringent conditions to said nucleotide sequence.

58. A host cell transformed or transfected with vector comprising a nucleic acid sequence according to claim 1, operatively linked to a suitable promoter, such that said host cell expresses a VEGF-B protein.

59. A host cell according to claim 58, wherein said VEGF-B protein comprises a sequence of amino acids substantially corresponding to an amino acid sequence selected from the group consisting of the amino acid sequence of Figure 1 (SEQ ID NO:2), the amino acid sequence of Figure 2 (SEQ ID NO:3), the amino acid sequence of Figure 4 (SEQ ID NO:5), the amino acid sequence of Figure 6 (SEQ ID NO:7), the amino acid sequence of Figure 8 (SEQ ID NO:9), the amino acid sequence of Figure 11 (SEQ ID NO:11), the amino acid sequence of Figure 13 (SEQ ID NO:13), and the amino acid sequence of Figure 15 (SEQ ID NO:15).

60. A diagnostic means for detecting VEGF-B in a test sample, said means comprising at least one pair of primers complementary to a nucleic acid sequence according to claim 1.

61. A method for obtaining at least one protein selected from the group consisting of proteins according to claim 18, and VEGF from a cell which expresses said at least one protein, said method comprising

- exposing the cell to heparin to induce release of said at least one protein, and
- collecting the released protein.

62. A method of making a vector suitable for expression of VEGF-B protein, said method comprising incorporating a nucleotide sequence according to claim 1, into a vector in operatively linked relation with a suitable promoter.

63. An isolated nucleic acid molecule which encodes a human VEGF-B molecule, wherein said isolated nucleic acid molecule hybridizes to a nucleic acid molecule encoding murine VEGF-B, at 42°C in 50% formamide, 5 x SSC pH 7.0 or 5 x SSPE buffer, 1% to 2% SDS, 5 to 10 x Denhardt's solution and 100 µg/ml of salmon sperm DNA.

1 Gly Arg Pro Val Val Pro Trp Ile Asp Val Tyr Ala Arg Ala Thr Cys Gln  
 3 GGA CGC CCA GTG GTG CCA TGG ATA GAC GTT TAT GCA CGT GGT GGC ACA TGC CAG  
 34 Pro Arg Glu Val Val Val Val Val Val Val Val Val Val Val Val Val Val Val  
 55 CCC AGG GAG GTG GTG GTG Cys Val Thr Val Val Val Val Val Val Val Val Val  
 106 Lys Gln Leu Val Pro Ser Cys Val Thr Val Val Val Val Val Val Val Val Val  
 157 Pro Asp Asp Gly Leu GGC CTG GAT GGC CTG GAT GGC CTG GAT GGC CTG GAT  
 208 Gln Ile Leu Met Ile Gln Tyr Pro Ser Ser Ser Ser Ser Ser Ser Ser Ser  
 259 CAG ATC CTC ATG ATC CAG TAC CCG AGC AGC AGT CAG CTG GGG GAG ATG TCC CTG  
 102 Glu Glu His Ser Gln Cys Glu Cys Arg Pro Lys Lys Arg Arg Val Leu  
 259 GAA GAA CAC AGC CAA TGT GAA TGC AGA CCA AAA AAA AGG AGA GTG CTG  
 Stop  
 310 TGA AGCCAGACAGCCCAGGATCCTCTGCCCGCCTTGACCCAGCGCCGTCAACGCCCTGACCCCC  
 376 GGACCTGCCGCTGCCGCTGCAGACGCCCGCCTTCCCTCCATTGCCAAGGGCGGCTTAGAGCTCAA  
 443 CCCAGACACCTGTAGGTGCCGGAAGCCGCGAAAGTGACAAAGCTGCTTCCAGACTCCACGGGCCCGG  
 510 CTGCTTTTATGGCCCTGCTTACAGGGACGAAGAGTGGAGCAGCAACCTCCTCAGTCTGGGAG  
 577 GTCACCTGCCCCAGGACCTGGACCTTTTAGAGAGCTCTCTGCCATCTTTTATCTCCAGAGCTGCCA  
 644 TCTAACAAATTGTCAGGAACCTCATGTCTCACCTCAGGGCCAGGTACTCTCTCACTTAACACCC  
 711 TGGTCAAGTGAGCATCTTCTGGCTGGCTGTCTCCCTCACTATGAAAACCCCAACTTCTACCAATA  
 778 ACGGGATTGGGTTCTGTTATGATAACTGTGACACACACACACTCACACTCTGATAAAAGAGAAC  
 845 TCTGATAAAAGAGATGGAAGACACTAAAAAATAAAAAA

(SEQ ID NOS:1 &amp; 2)

FIG. 1

(SEQ ID NOS: 1 & 3)

**FIG. 2**

GAGCCCCCTG CTCCGTGCGC TGCTGCTTGT TGCACTGCTG CAGCTGGCTC  
 GCACCCAGGC CCTGTGTCC CAGTTGATG GCCCCAGCCA CCAGAAGAAA  
 GTGGTGCCAT GGATAGACGT TTATGCACGT GCCACATGCC AGCCAGGGA  
 GGTGGTGGTG CCTCTGAGCA TGGAACATCAT GGGCAATGTG GTCAAACAAC  
 TAGTGCCAG CTGTGTGACT GTGCAGCGCT GTGGTGGCTG CTGCCCTGAC  
 GATGGCCTGG AATGTGTGCC CACTGGGCAA CACCAAGTCC GAATGCAGAT  
 CCTCATGATC CAGTACCCGA GCAGTCAGCT GGGGAGATG TCCCTGGAAG  
 AACACAGCCA ATGTGAATGC AGACCAAAA AAAAGGAGAG TGCTGTGAAG  
 CCAGACAGCC CCAGGATCCT CTGCCCCGCT TGCACCCAGC GCCGTCAACG  
 CCTGACCCC CGGACCTGCC GCTGCCGCTG CAGACGCCGC CGCTTCCTCC  
 ATTGCCAAGG GCGGGGCTTA GAGCTCAACC CAGACACCTG TAGGTGCCGG  
 AAGCCGCGAA AGTGA  
 (SEQ ID NO: 4)

FIG. 3

MSPLLRRLLL VALLQLARTQ APVSQFDGPS HQKKVVPWID VYARATCQPR  
 EVVPLSMEL MGNVVKQLVP SCVTVQRCGG CCPDDGLECV PTGQHQVRMQ  
 ILMIQYPSQ LGEMSLEHS QCECRPKKE SAVKPDSPRI LCPPCTQRRQ  
 RPDPRTCRCR CRRRRFLHCQ GRGLELNPDT CRCRKP RK  
 (SEQ ID NO: 5)

FIG. 4

ACCATGAGCC CCCTGCTCCG TCGCCTGCTG CTTGTTGCAC TGCTGCAGCT  
 GGCTCGCACC CAGGCCCTG TGTCCAGTT TGATGGCCCC AGCCACCAGA  
 AGAAAGTGGT GCCATGGATA GACGTTTATG CACGTGCCAC ATGCCAGCCC  
 AGGAGGTGG TGGTGCTCT GAGCATGGAA CTCATGGGCA ATGTGGTCAA  
 ACAACTAGTG CCAGCTGTG TGA CTGTGGT GCGCTGTGGT GGCTGCTGCC  
 CTGACGATGG CCTGGAAATGT GTGCCCACTG GGCAACACCA AGTCCGAATG  
 CAGGTACCAG GGCCTATGGG TCAGATCCTC ATGATCCAGT ACCGAGCAG  
 TCAGCTGGG GAGATGTCCC TGAAGAACA CAGCCAATGT GAATGCAGAC  
 CAAAAA AAAA GGAGAGTGCT GTGAAGCCAG ACAGCCCCG GATCCTCTGC  
 CCGCCTTGCA CCGAGGCCG TCAACGCCCT GACCCCCGA CCTGCCGCTG  
 CCGCTGCAGA CGCCGCCGCT TCCTCCATTG CCAAGGGCGG GGCTTAGAGC  
 TCAACCCAGA CACCTGTAGG TGCCGGAAGC CGCGAAAGTG A  
 (SEQ ID NO: 6)

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FIG. 5

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MSPLLRRLLL VALLQLARTQ APVSQFDGPS HQKKVVPWID VYARATCQPR  
 EVVPLSMEL MGNVVKQLVP SCVTVQRCCG CCPDDGLECV PTGQHQVRMQ  
 VPGPMGQILM IQYPSSQLGE MSLEHSQCE CRPKKESAV KPDSPRILCP  
 PCTQRRQRPD PRTCRCRCRR RFLHCQGRG LELNPDTCRC RKPRK  
 (SEQ ID NO: 7)

FIG. 6

ACCATGAGCC CCCTGCTCCG TCGCCTGCTG CTGTGTGCAC TGCTGCAGCT  
 GGCTCGCACC CAGGCCCCCTG TGTCCCAGTT TGATGGCCCC AGCCACCAGA  
 AGAAAGTGGT GCCATGGATA GACGTTTATG CACGTGCCAC ATGCCAGCCC  
 AGGAGGTGG TGGTGCTCTT GAGCATGGAA CTCATGGGCA ATGTGGTCAA  
 ACAACTAGTG CCCAGCTGTG TGA CTGTGCA GCGTGTGGT GGCTGCTGCC  
 CTGACGATGG CCTGGAATGT GTGCCCCACTG GGCAACACCA AGTCCGAATG  
 CAGATCCTCA TGATCCAGTA CCCGAGCAGT CAGCTGGGG AGATGTCCCT  
 GGAAGAACAC AGCCAATGTG AATGCAGACC AAAAAAAAAA AGGAGAGTGC  
 TGTGA

(SEQ ID NO:8)

FIG. 7

MSPLLRRLLL VALLQLARTQ APVSQFDGPS HQKKVVPWID VYARATCQPR  
 EVVVP LSMEL MGNVVKQLVP SCVTVQRCGG CCPDDGLECV PTGQHQVRMQ  
 ILMIQYPSSQ LGEMSLEEHS QCECRPKKKR RVL

(SEQ ID NO:9)

FIG. 8



mVEGF-B 167  
mVEGF 164  
hPlGF  
mPDGF A  
mPDGF B

mVEGF-B 167	Q V R M Q I L M I Q Y P S S Q	- - - - -	L G E M S S L E E H S Q
mVEGF 164	N I T M Q I M R I K P H Q S Q	- - - - -	H I G E M S F L Q H S R
hPlGF	N V T M Q L L K I R S G D R P	- - - - -	S Y V E L T F S Q H V R
mPDGF A	H R S V K V A K V E Y V R K K K	- K L F K K P I	K E V Q V R L E E H L E
mPDGF B	M R P V Q V R K I E I V R K K K	- - - - -	L E E H L L A

mVEGF-B 167  
mVEGF 164  
hPLGF  
mPDGF A  
mPDGF B

mVEGF-B 167  
--PDPRTCRCRCRRRRFLH C QGRGLELNP  
L F V Q D P Q T C K C S C K N T D - S R C K A R Q L E L N E  
mVEGF 164  
hPIGF  
mPDGF A  
mPDGF B  
VTIRTVIRIRPPPKGKH[R]KFKHTHDKAALKE

mVEGF-B 167  
 mVEGF 164  
 mPlGF  
 mPDGF A  
 mPDGF B

D	T	C	R	C	R	K	P	R	K
R	T	C	R	C	D	K	P	R	R

T L G A

FIG. 9B

**FIG. 9B**

ACCATGAGCC CTCTGCTCCG CCGCCTGCTG CTCGCCGCAC TCCTGCAGCT  
 GGCCCCCGCC CAGGCCCTG TCTCCAGCC TGATGCCCCCT GCCACCAGA  
 GGAAGTGGT GTCATGGATA GATGTGATA CTCGCGCTAC CTGCCAGCCC  
 CGGAGGTGG TGGTGCCCTT GACTGTGGAG CTCATGGCA CCGTGGCAA  
 ACAGCTGGTG CCCAGCTGCG TGA CTGTGCA GCGCTGTGGT GGTGTGCC  
 CTGACGATG CCTGGAGTG GTGCCCACTG GGCAGCACCA AGTCCGGATG  
 CAGATCCTCA TGATCCGTA CCCGAGCAGT CAGCTGGGG AGATGTCCCT  
 GGAAGAACAC AGCCAGTGTG AATGCAGACC TAAAAAAG GACAGTGCTG  
 TGAAGCCAGA CAGCCCCAGG CCCCTCTGCC CACGTGCAC CCAGCACAC  
 CAGCGCCCTG ACCCCCGGAC CTGCCGCTGC CGTGGCCGAC GCCGAGCTT  
 CCTCCGTTGC CAAGGCGGG GCTTAGAGCT CAACCCAGAC ACCTGCAGGT  
 GCCGGAAGCT GCGAAGTGA  
 (SEQ ID NO:10)

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FIG. 10

MSPLLRLLL AALLQLAPAQ APVSQPDAPG HQRKVSWID VYTRATCQPR  
 EVVPLTVEL MGTVAQLVP SCVTVQRCGG CCPDDGLECV PTGQHQVRMQ  
 ILMIRYPSSQ LGEMSLEHS QCECRPKKD SAVKPDSPRP LCPRCTQHHQ  
 RPDPRTCRCR CRRRSFLRCQ GRGLELNPDT CRCRKLRR  
 (SEQ ID NO:11)

FIG. 11

ATGAGCCCCC TGCTCCGTCG CCTGCTGCTT GTTGCACTGC TGCAGCTGGC  
 TCGCACCCAG GCCCTGTGT CCCAGTTGA TGGCCCCAGC CACCAGAAGA  
 AAGTGGTGCC ATGATAGAC GTTATGCAC GTGCCACATG CCAGCCCAGG  
 GAGGTGGTGG TGCCCTCTGAG CATGGAATC ATGGGCAATG TGGTCAAACA  
 ACTAGTGCCC AGCTGTGTGA CTGTGCAGCG CTGTGGTGGC TGCTGCCCTG  
 ACGATGGCCT GGAATGTGTG CCCACTGGGC AACACCAAGT CCGAATGCAG  
 ATCCTCATGA TCCAGTACCC GAGCAGTCAG CTGGGGGAGA TGTCCCTGGA  
 AGAACACAGC CAATGTGAAT GCAGACCATA AAAAAGGAG AGTGCTGTGA  
 AGCCAGACAG GGTGCCCATA CCCACCAACC GTCCCCAGCC CCGCTCTGTT  
 CCGGGCTGGG ACTCTACCC GGGAGCATCC TCCCCAGCTG ACATCATCCA  
 TCCCACTCCA GCCCCAGGAT CCTCTGCCCC CTTGCAACC AGCGCCGTCA  
 ACGCCCTGAC CCCCGGACCT GCCGCTGCCG CTGCAGACGC CGCCGCTTCC  
 TCCATTGCCA AGGGCGGGC TTAG  
 (SEQ ID NO:12)

FIG. 12

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MSPLLRLLL VALLQLARTQ APVSQFDGPS HQKKVVPWID VYARATCQPR  
 EVVPLSMEL MGNVVKQLVP SCVTVQRCGG CCPDDGLECV PTGQHQVRMQ  
 ILMIQPSSQ LGEMSLEHS QCECRPKKE SAVKPDRAI PHHRPQPRSV  
 PGWDSTPGAS SPADI IHPTP APGSSARLAP SAVNALTPGP AAAAADAAS  
 SIAKGA  
 (SEQ ID NO:13)

FIG. 13

ATGAGCCCTC TGCTCCGCCG CCTGCTGCTC GCCGCACTCC TGCAGCTGGC  
 CCCC GCCCAG GCCCCTGTCT CCCAGCCTGA TGCCCCCTGGC CACCAGAGGA  
 AAGTGGTGTC ATGATAGAT GTGTATACTC GCGCTACCTG CCAGCCCCGG  
 GAGGTGGTGG TGCCCTTGAC TGTGGAGCTC ATGGGCACCG TGGCCAAACA  
 GCTGGTGCCC AGCTGCGTGA CTGTGCAGCG CTGTGGTGGC TGCTGCCCTG  
 ACGATGGCCT GGAGTGTGTG CCACTGGG AGCACCAAGT CCGATGCAG  
 ATCCTCATGA TCCGGTACCC GAGCAGTCAG CTGGGGGAGA TGTCCCTGGA  
 AGAACACAGC CAGTGTGAAT GCAGACCTAA AAAAAGGAC AGTGCTGTGA  
 AGCCAGACAG GGCTGCCACT CCCACCACC GTCCCCAGCC CCGTCTCTGT  
 CCGGGCTGGG ACTCTGCCCC CGAGCACCC TCCCCAGCTG ACATCACCCA  
 TCCCACTCCA GCCCAGGCC CCTCTGCCCA CGTGACCC AGCACCAACA  
 GCGCCCTGAC CCCCAGACCT GCCGCCGCC CTGCCGACGC CGCAGCTTCC  
 TCCGTTGCCA AGGCGGGGC TTAG  
 (SEQ ID NO: 14)

FIG. 14

MSPLLRLL AALLQLAPAQ APVSQPDAPG HQRKVVSUID VYTRATCQPR  
 EVVPLTVEL MGTVAKQLVP SCVTVQRCGG CCPDDGLECV PTGQHQRMQ  
 ILMIRYPSSQ LGEMSLEHS QCECRPKKD SAVKPDRAAT PHHRPQPRSV  
 PGWDSAPGAP SPADITHPTP APGPSAHAAP STTSALTPGP AAAADAAAS  
 SVAKGA  
 (SEQ ID NO: 15)

FIG. 15



mVEGF-B186	M	S	P	L	L	R	R	L	L	V	A	L	L	Q	L	A	R	T	Q	A	P	V	S	Q	F	D	G	P	S
hVEGF-B186	M	S	P	L	L	R	R	L	L	A	A	L	L	Q	L	A	P	A	Q	A	P	V	S	Q	P	D	A	P	G
mVEGF-B167	M	S	P	L	L	R	R	L	L	V	A	L	L	Q	L	A	R	T	Q	A	P	V	S	Q	F	D	G	P	S
hVEGF-B167	M	S	P	L	L	R	R	L	L	A	A	L	L	Q	L	A	P	A	Q	A	P	V	S	Q	P	D	A	P	G

mVEGF-B186	H	Q	K	K	V	V	P	W	I	D	V	Y	A	R	A	T	C	Q	P	R	E	V	V	P	L	S	M	E	L
hVEGF-B186	H	Q	R	K	V	V	S	W	I	D	V	Y	T	R	A	T	C	Q	P	R	E	V	V	P	L	T	V	E	L
mVEGF-B167	H	Q	K	K	V	V	P	W	I	D	V	Y	A	R	A	T	C	Q	P	R	E	V	V	P	L	S	M	E	L
hVEGF-B167	H	Q	R	K	V	V	S	W	I	D	V	Y	T	R	A	T	C	Q	P	R	E	V	V	P	L	T	V	E	L

mVEGF-B186	M	G	N	V	V	K	Q	L	V	P	S	C	V	T	V	Q	R	C	G	G	C	C	P	D	D	G	L	E	C	V
hVEGF-B186	M	G	T	V	A	K	Q	L	V	P	S	C	V	T	V	Q	R	C	G	G	C	C	P	D	D	G	L	E	C	V
mVEGF-B167	M	G	N	V	V	K	Q	L	V	P	S	C	V	T	V	Q	R	C	G	G	C	C	P	D	D	G	L	E	C	V
hVEGF-B167	M	G	T	V	A	K	Q	L	V	P	S	C	V	T	V	Q	R	C	G	G	C	C	P	D	D	G	L	E	C	V

mVEGF-B186	P	T	G	Q	H	Q	V	R	M	Q	I	L	M	I	Q	Y	P	S	S	Q	L	G	E	M	S	L	E	E	H	S
hVEGF-B186	P	T	G	Q	H	Q	V	R	M	Q	I	L	M	I	R	Y	P	S	S	Q	L	G	E	M	S	L	E	E	H	S
mVEGF-B167	P	T	G	Q	H	Q	V	R	M	Q	I	L	M	I	Q	Y	P	S	S	Q	L	G	E	M	S	L	E	E	H	S
hVEGF-B167	P	T	G	Q	H	Q	V	R	M	Q	I	L	M	I	R	Y	P	S	S	Q	L	G	E	M	S	L	E	E	H	S

FIG. 16A

mVEGF-B <sub>186</sub>	Q C E C R P K K K E S A V K P D R V A I P H H R P Q P R S V
hVEGF-B <sub>186</sub>	Q C E C R P K K K D S A V K P D R A T P H H R P Q P R S V
mVEGF-B <sub>167</sub>	Q C E C R P K K K E S A V K P D S P R I L C P P C T Q R R Q
hVEGF-B <sub>167</sub>	Q C E C R P K K K D S A V K P D S P R P L C P R C T Q H H Q
mVEGF-B <sub>186</sub>	P G W D S T P G A S S P A D I I H P T P A P G S S A R L A P
hVEGF-B <sub>186</sub>	P G W D S A P G A P S P A D I T H P T P A P G P S A H A A P
mVEGF-B <sub>167</sub>	R P D P R T C R C R C R R R S F L H C Q G R G L E L N P D T
hVEGF-B <sub>167</sub>	R P D P R T C R C R C R R R S F L R C Q G R G L E L N P D T
mVEGF-B <sub>186</sub>	S A V N A L T P G P A A A A D A A S S I A K G G A
hVEGF-B <sub>186</sub>	S T T S A L T P G P A A A A D A A S S V A K G G A
mVEGF-B <sub>167</sub>	C R C R K P R K
hVEGF-B <sub>167</sub>	C R C R K L R R

FIG. 16B

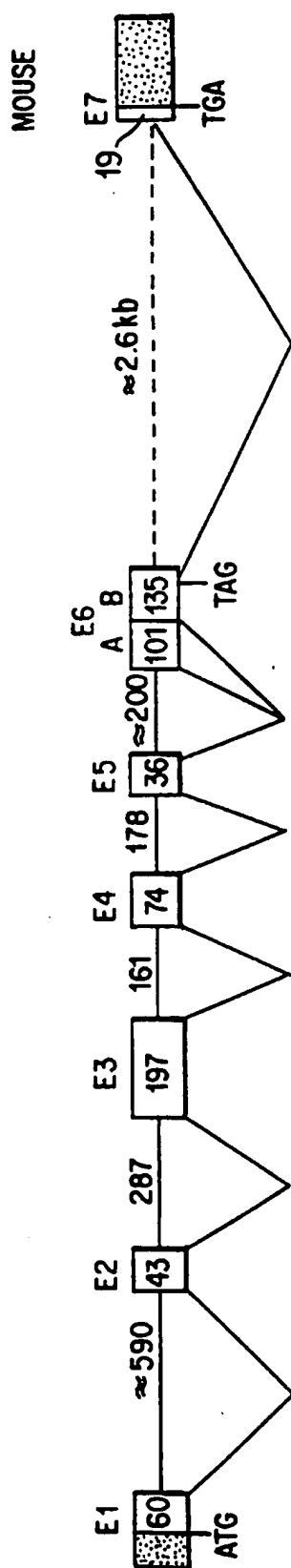


FIG. 17

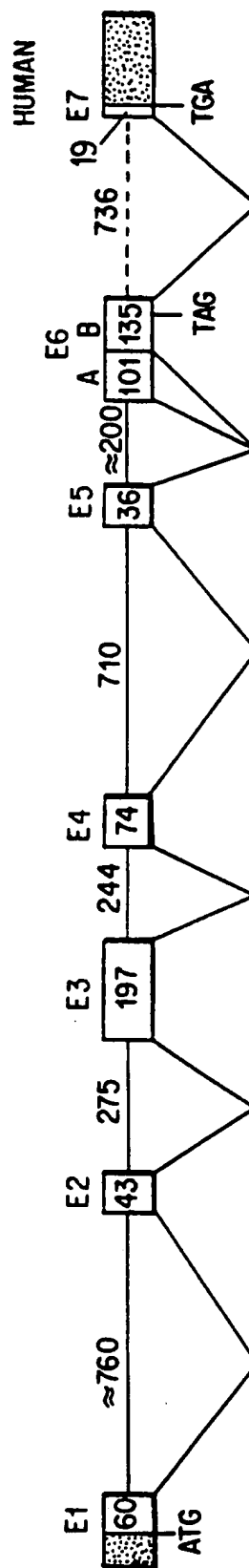


FIG. 17A

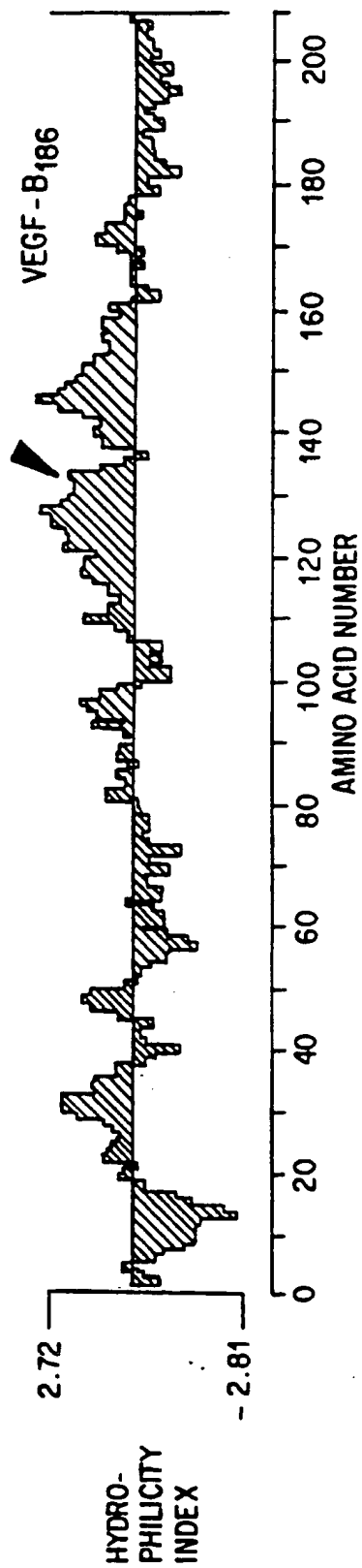


FIG. 18

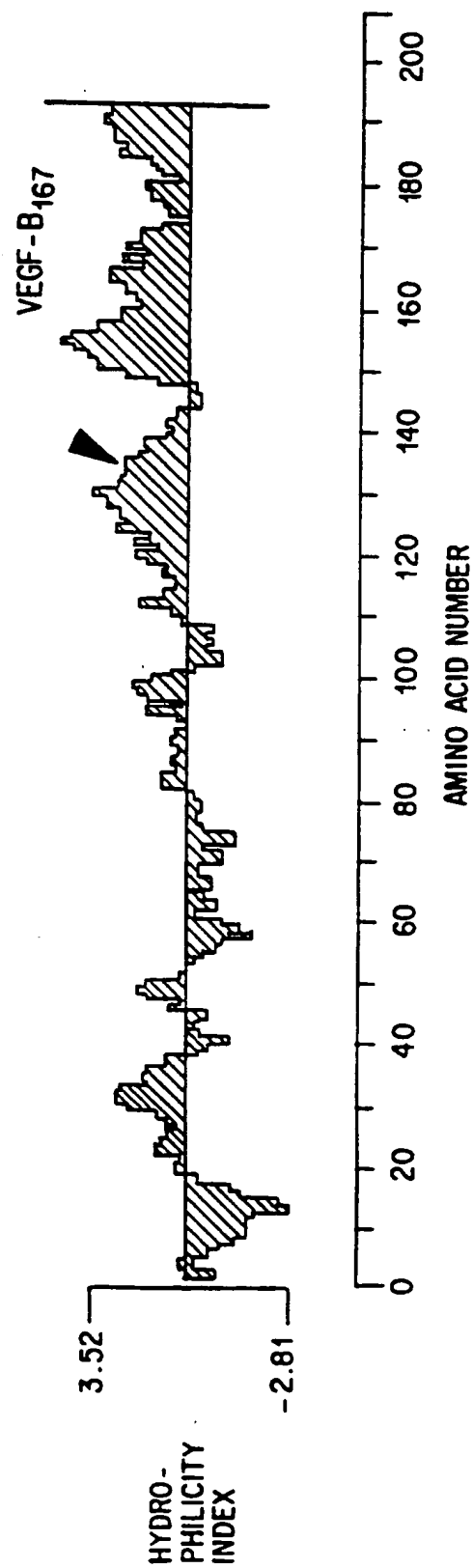


FIG. 18A

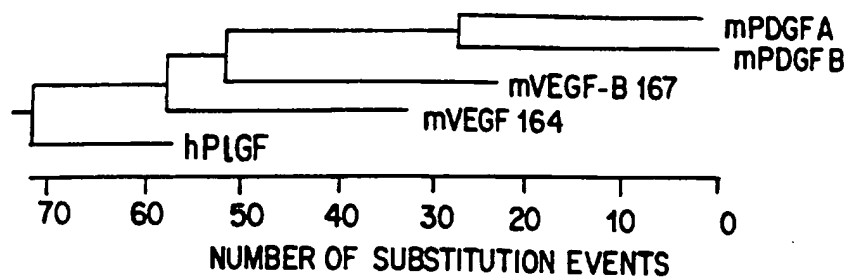


FIG. 19

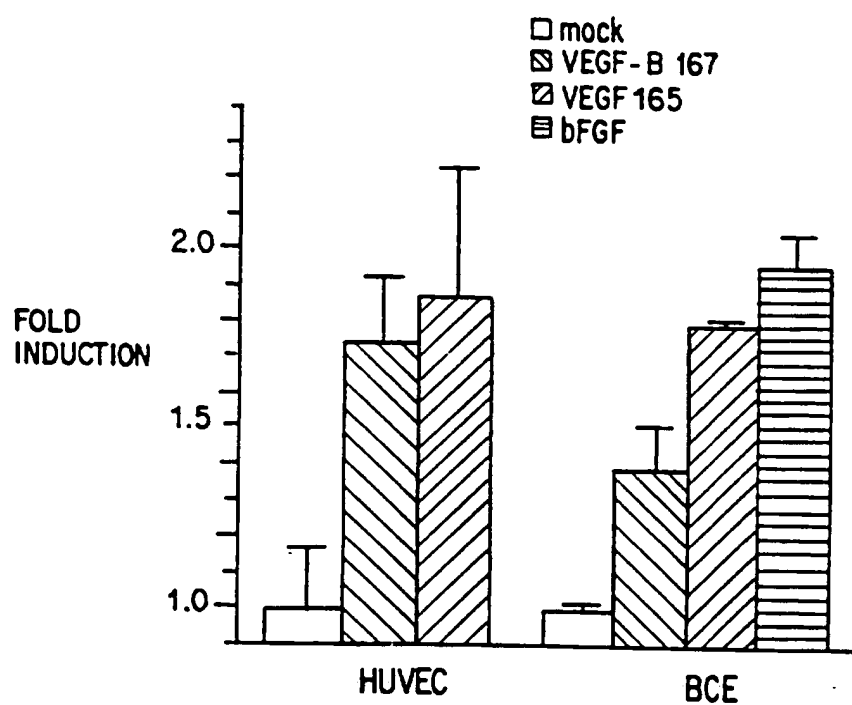


FIG. 20

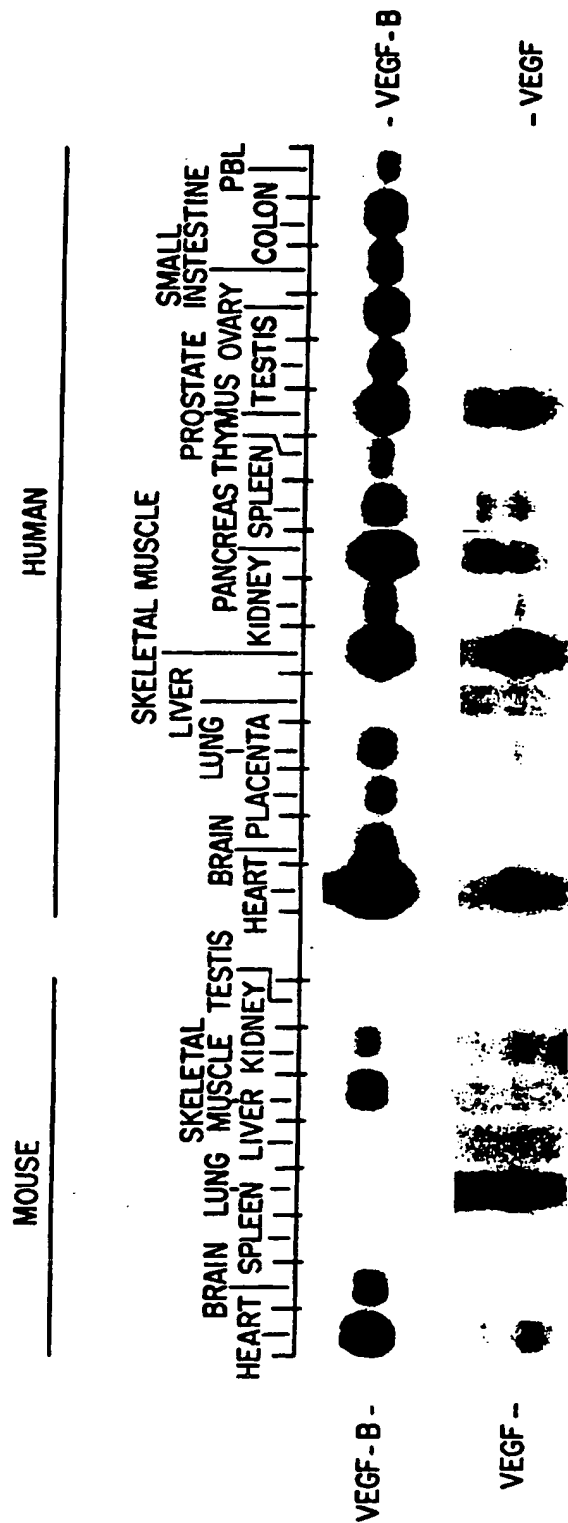


FIG. 21

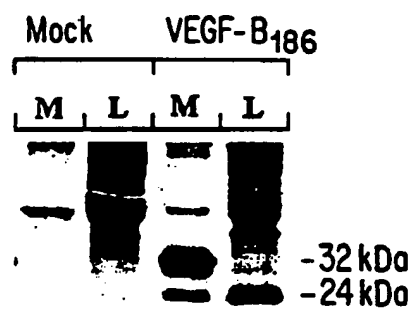


FIG. 22

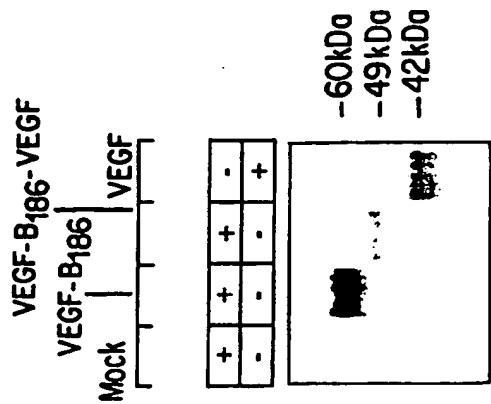


FIG. 23C

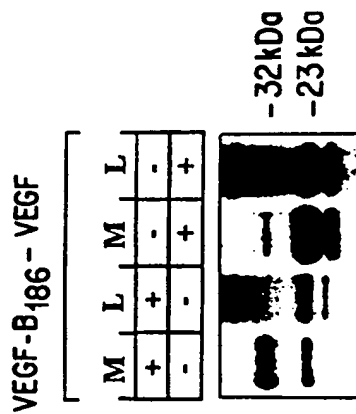


FIG. 23B

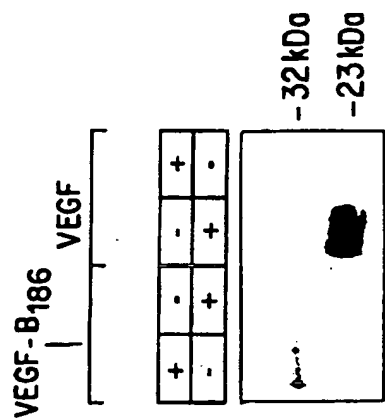


FIG. 23A

Antibody to  
VEGF-B  
VEGF

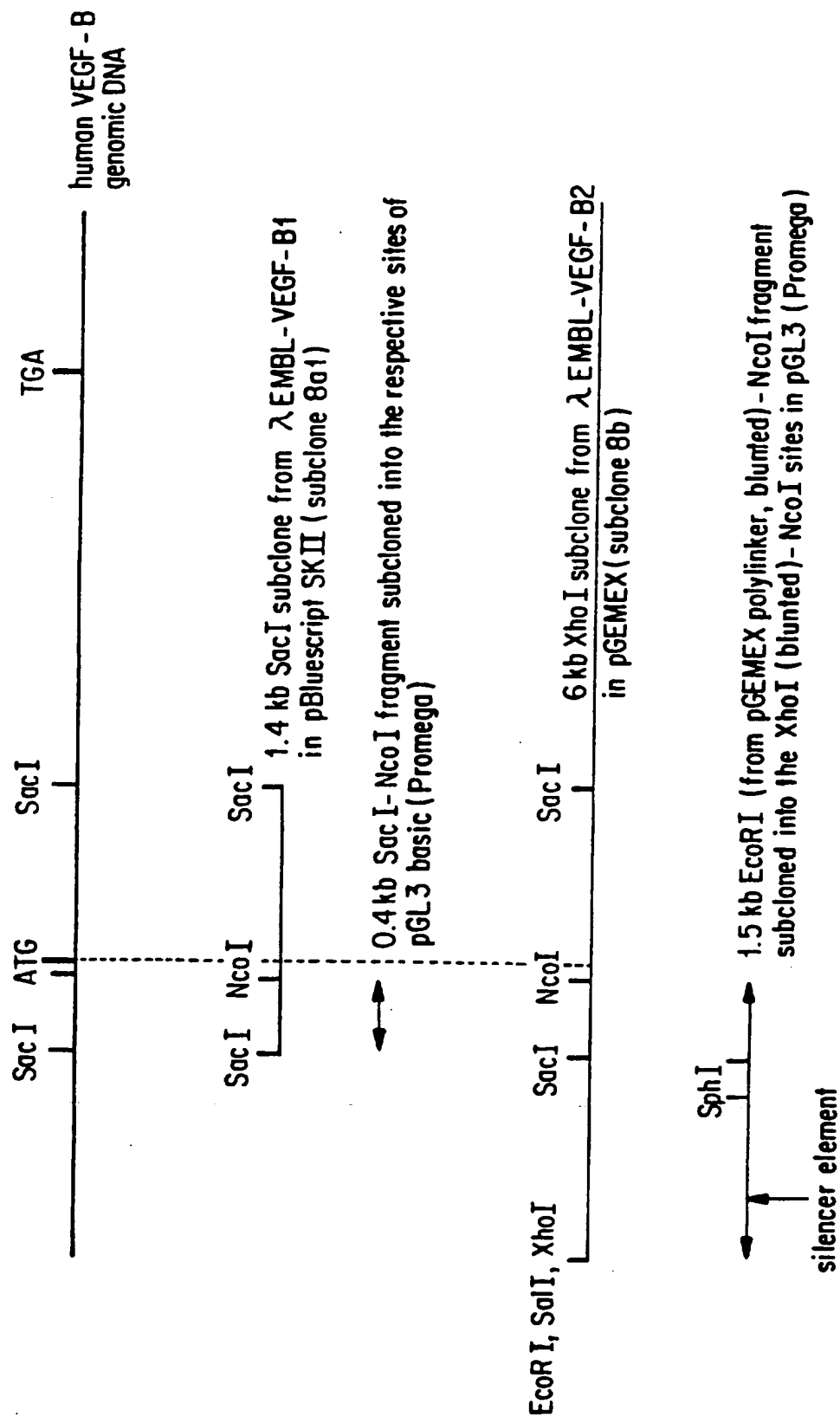


FIG. 24

1 ctcgagatct gtttgttgtc ttggaacaat acggtttaga ggtgactggc  
Xho I  
51 gggtgācgag aacatatgcg agttcaccta agagaaaagc tgaatgaggc  
101 aatgcctctt cctgaccata tctcttactc agataactat agaatttatt  
151 gtccagtaaa gggta tatta aaaaatcata ttaaagtca tacagtgaag  
201 ttgtccaggg aaatcaagac <sup>silencer binding site 2</sup> taacagtcct cactctgaca ataataaaca  
251 gggggattcc ctcaagatag actaggacat gacccacac tggcaggtag  
301 tagtaccaga aaagaacgca tggaaaaatct ttaccttatg cttgaggtag  
351 ggaccaggct aaagtgaagg ccagaccctaa aattctatct aaaataaatc  
401 cacaatcgaa gaaaatatgt ggtgtacagg tatagaatgt cttactgga  
451 tcattgaaat agtaagataa attcaacttt ttacattgtt ttcttttctt  
501 ccagttaggg cttgagacct tcgtctctgg agagtgactg tcaattggag  
551 ccctgcttctc tgggtttctg gccagggggg ttgtggatgc ttaacatgtg  
601 cctttcacag gacacttctt taccacagca gtggccangt gtgcatccca

FIG. 25A

651 cgaccaggcc tccctctcac ggaacatctg ttgagactag gagatgcctg  
701 gtgactgttg cctgacctgt gtcctgtgta tttctgacaa gagccactct  
751 caaagaccct ggccaggagg agagttaggt tccagtgtag gtcagctcag  
801 acagatggag gccacagaaan caaacatggg aaatcacaga agtaggttta  
851 ttactcacag atccctatcc caaccacca ggtgccctct cctccagggc  
901 caacagaggc atccttcagc aggagcgaca acggctaggg cagggcaag  
951 ccgccaccat ccgagccaac ccaggccccg agatcgtgcc ccggggcgcc  
1001 gggccctgag gggctcacct ggatggggcc tgcattgcgtt cccgctttgc  
1051 ttccttccct ggacggcccc ctccccgaa acgcgcgcc <sup>Sph I</sup> aataaagtga  
1101 ttcgcagagc tcgtgtgcgg ctccctcctt aaggcccgac gcccccgcc  
1151 ccggcctcgc <sup>Sac I</sup> caagggcagc gccccggcct ccgggtagtg gcggccggcg  
1201 actggggagc ccagcctcct gggcgggtgcg tccccctccc cctgccgcgg  
1251 cgggaggcgg gagggggtgt gtggaggagg cggggccccg cgacggcctc

FIG. 25B

1301 gcccccccac cccgccgcc cgcggcgcc cccggggccc ggtggggagc  
1351 gcgtgtctgg gtacatgag ccgcctgcc gccagccgg gccagcccc  
1401 ccgccgcccc cgcgtcccc gccgcgctg cccggcccca ccggccgccc  
1451 gcccgccgg ctctccggc cgcttcgct gcgctgcntg cgctgcctgc  
1501 acccagggt cggagggg ccgcggagga gccggcccc gcgccccggcc  
... Nco I site is about 30 bp downstream) (SEQ ID NO:17)

FIG. 25C

## INTERNATIONAL SEARCH REPORT

 International application No.  
 PCT/US96/02957
**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) : Please See Extra Sheet.

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 435/6, 7.1, 240.2, 320.1; 514/2; 530/350, 387.9, 388.1, 388.24; 536/23.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 Please See Extra Sheet.
**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FERRARA et al. The Vascular Endothelial Growth Factor Family of Polypeptides. Journal of Cellular Biochemistry. 1991, Vol. 47, pages 211-218, especially the abstract.	1-57
A, P	WO 95/24473 A (HUMAN GENOME SCIENCES, INC.) 14 September 1995, see entire document.	1-57
A	KLAGSBRUN et al. Regulators of Angiogenesis. Annual Review of Physiology. 1991, Vol. 53, pages 217 to 239, see entire document.	1-57
A	FOLKMAN et al. Angiogenesis. The Journal of Biological Chemistry. 05 June 1992, Vol. 267, No. 16, pages 10931 to 10934, see entire document.	1-57

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		

 Date of the actual completion of the international search  
 31 MAY 1996

 Date of mailing of the international search report  
 21 JUN 1996

 Name and mailing address of the ISA/US  
 Commissioner of Patents and Trademarks  
 Box PCT  
 Washington, D.C. 20231

 Authorized officer  
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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/02957

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/02957

## A. CLASSIFICATION OF SUBJECT MATTER: IPC (6):

A61K 38/17; C07K 14/47, 16/18; C12N 5/02, 5/06, 15/12, 15/70, 15/79; C12Q 1/68; G01N 33/53

## A. CLASSIFICATION OF SUBJECT MATTER: US CL :

435/6, 7.1, 240.2, 320.1; 514/2; 530/350, 387.9, 388.1, 388.24; 536/23.5

## B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

### APS, DIALOG

search terms: VEGF, VEGF-B, vector?, plasmid?, pharmaceutical?, antibod?, monoclonal?, 293EBNA, insect, COS  
endothelial, mesodermal, diagnost?, detect?, polymerase chain reaction, dimer?, heparin

## BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-17, 35-40 and 43, drawn to DNA encoding VEGF-B protein, vector comprising said DNA, host cell comprising said protein, diagnostic method using said DNA.

Group II, claims 18-32 and 45-53, drawn to VEGF-B protein and method of promoting release of said protein.

Group III, claims 33-34, 41-42 and 44, drawn to anti-VEGF-B antibody, diagnostic method using said antibody.

Group IV, claims 54-56, drawn to antisense vector and method of retarding expression using said vector.

Group V, claim 57, drawn to DNA comprising VEGF-B promoter fragment.

The inventions listed as Groups I-V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the DNA encoding VEGF-B, VEGF-B protein, antibody against VEGF-B, vector encoding VEGF-B antisense molecule, and DNA comprising VEGF-B promoter are chemically, biochemically, structurally, and functionally different and distinct from each other and thus share no common technical feature. The methods of each Group also do not share a common technical feature because each method comprises steps different from the steps of the other methods, and the products of the other groups are neither required for nor used in the methods of the inventions of the other groups. Accordingly, the claims are not so linked by a special technical feature within the meaning of PCT Rule 13.2 so as to form a single inventive concept.

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